POWER PLANT ENGINEERING

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San Francisco Pumping Stations

TWO EARTHQUAKE-PROOF SALT-WATER PUMPING PLANTS; DETAILS OF EQUIPMENT. BY CHARLES W. GEIGER

IN ORDER TO GUARD against a conflagration similar to that which followed the earthquake in 1906, San Francisco has constructed two salt-water pumping stations which are designed to withstand a similar earthquake and equipped to supply 24,000 gal. of water per minute into the water mains in case the earthquake should cut the distributing mains, from the storage reservoirs, from which they obtain their supply.

The fuel oil is stored in five subterranean steel tanks, and the fresh water for operating the plant is stored in six reinforced concrete tanks located under the boiler room of the station.

In order to insure satisfactory operation in the hurry and confusion which may prevail during an emergency, the machinery installed is of the simplest types. The number of parts requiring attention or adjustment has been reduced to a minimum and the design and arrangement is such as to render it almost impossible that an

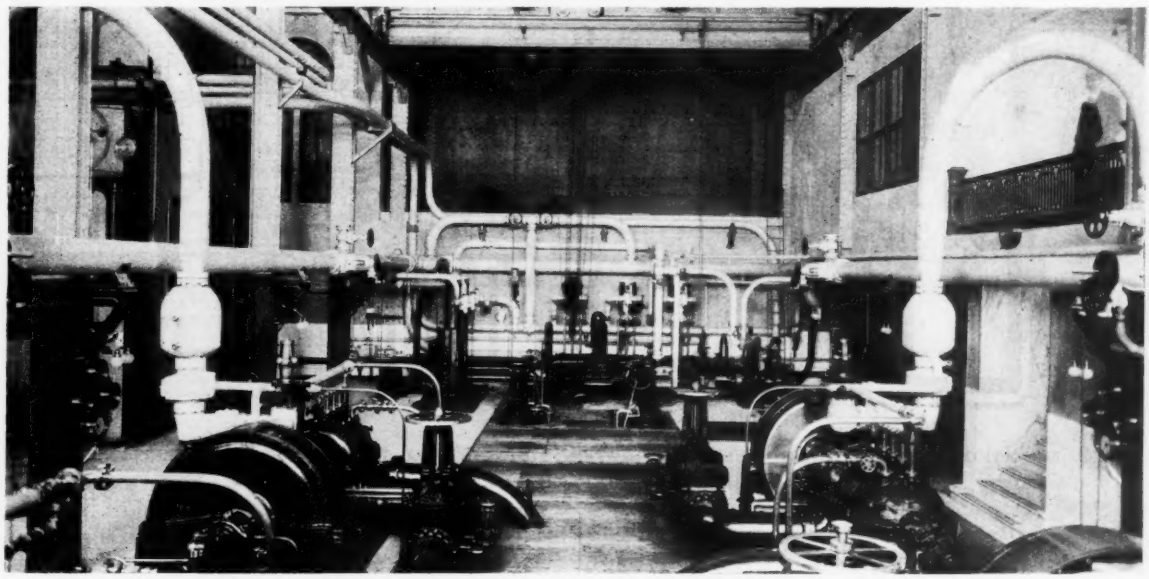


FIG. 1. INTERIOR OF SECOND AND TOWNSEND ST. STATION.

The possibility that gas and fresh water mains and electric power wires may be broken, and that means of transportation may be interrupted, has made it imperative that each station be independent of all outside sources of power, fuel or supplies for at least 96 hr., while operating at full capacity.

One of the pumping stations is built at Fort Mason, at the Bay shore, and the other is built at Townsend and Second streets, about two blocks from the bay, with which the pumps are connected by means of a reinforced concrete tunnel.

error on the part of an operator will necessitate the shutting down of any considerable portion of a station.

In order to secure flexibility of operation, and to minimize the effect of accidents on the amount of water delivered, a number of separate pumping units have been installed in each station, all of which, on account of the greater economy in repair parts, are of the same size. The capacity of each unit is approximately 3000 gal. per min. against a pressure of approximately 300 lb. to the square inch. Each station is equipped with

four units, with space provided for the installation of two additional units when necessary.

The equipment of the Townsend St. station consists of four turbine-driven centrifugal pumps of the non-condensing type, 750-hp., 1800 r.p.m.. Eight 350-hp. horizontal water-tube boilers supply steam to the turbines.

Because of its low cost, the ease and safety with which large quantities can be stored and the minimum amount of labor that is required to feed it to the furnace of a boiler, crude oil is used.

The accompanying illustrations show the arrangement of the Townsend St. pumping station as it will ultimately be equipped with six steam turbine, multi-stage, turbine pumps, marked 1, 2, 3, 4, 5, 6; six batteries of water-tube boilers, marked 1, 2, 3, 4, 5, 6; four boiler feed pumps, marked 1, 2, 3, 4; three deep well pumps, marked 1, 2, 3, and three feed water heaters, marked 1, 2, 3.

At present there is installed only the steam turbine pumps, marked 1, 2, 3, 4; the batteries of water-tube boilers, marked 1, 2, 3, 4; the boiler feed pumps, marked 1, 2, 3; the deep well pumps, marked 1 and 2, and the feed-water heaters, marked 1 and 2; but the foundations have been provided, and all main pipes, valves and fittings have been installed in such a manner that the additional equipment for which space has been provided can be installed at some future time, without in any way interfering with the operation of that part of the plant which is now installed.

Details of Boilers

Each of the boilers has a total heating surface of approximately 3500 sq. ft. They are designed and constructed for a working pressure of 200 lb. per sq. in.

A trained crew is maintained at each station ready for immediate service. One battery of boilers is maintained constantly with steam, and hot water is circulated through the remaining boilers so that steam may quickly be raised in all the boilers.

The boilers are constructed entirely of open hearth steel plates and cold drawn seamless steel tubes. They are so proportioned that the maximum stress in the material under working conditions will in no case exceed 1/6 of its ultimate strength.

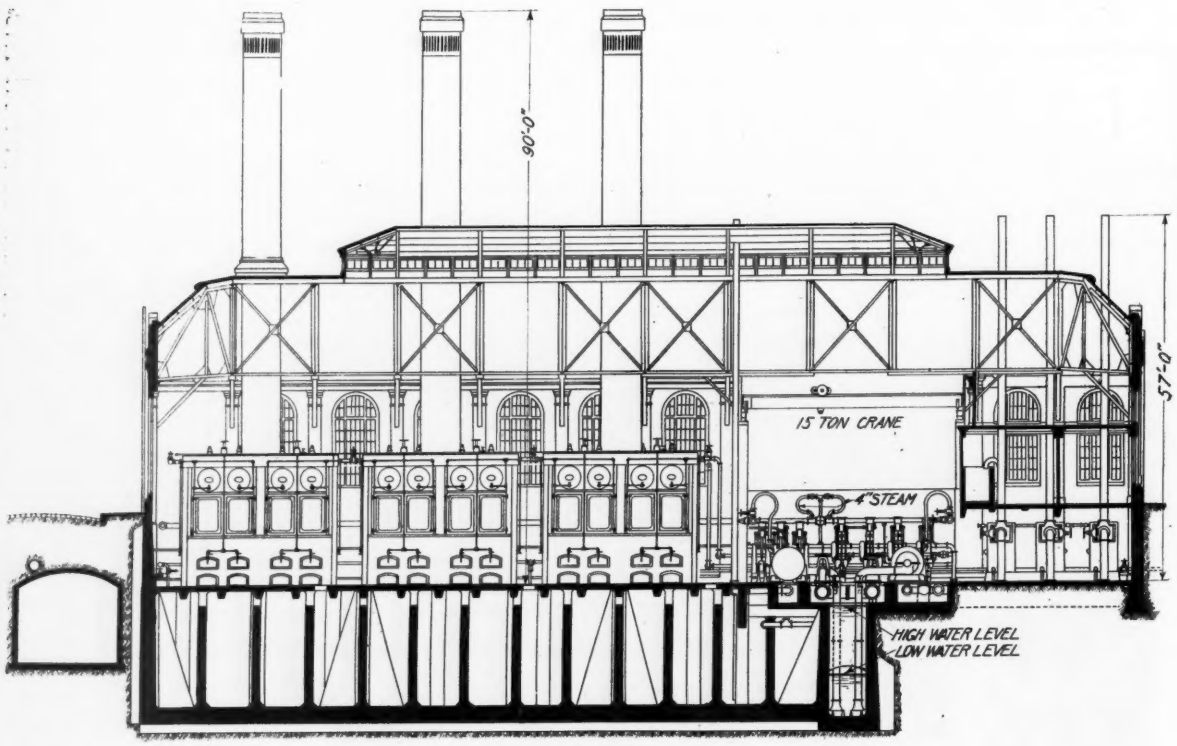


FIG. 2. ELEVATION OF SECOND AND TOWNSEND ST. STATION, SHOWING FUEL TANKS TO EXTREME LEFT AND WATER STORAGE TANKS UNDER THE ENGINE ROOM

The boilers are supported upon structural steel framing. Especial care was observed in the design and construction of the boilers to provide for easy access to all parts for cleaning, repairs or renewal. In so far as it was practicable, all calked seams are located so as to be accessible without removing the boiler setting, and all seams are located so as to be accessible for calking without removing any of the tubes.

All steel used in the manufacture of the boilers was manufactured by the open hearth process, and the specification required that it should contain not more than 0.04 of 1 per cent of phosphorous nor more than 0.03 of 1 per cent sulphur.

All steel plates were tested as follows:

Four test pieces were cut from each steel plate, one

piece from each corner. One of these pieces was required to show a tensile strength of not less than 56,000 lb. nor more than 62,000 lb. per sq. in., with an elongation in a parallel test piece 8 in. in length, of not less than 25 per cent and a reduction in area at the point of fracture of at least 50 per cent. The remaining test pieces were required to endure bending double, closing up completely upon themselves, without showing a sign of fracture, when bent cold without heat treatment, or after being heated to a cherry red and quenched in water at a temperature of about 70 deg. F., and failure to undergo the foregoing tests by any test piece was a cause for the plate being rejected.

Rods for rivets and for screw steel stay bolts were tested as follows:

Four test pieces were prepared from each heat. Two of these pieces were required to show a tensile strength of not less than 50,000 nor more than 55,000 lb. per sq. in., with an elongation of not less than 28 per cent in 8 in., and a reduction in area at the point of fracture of not less than 55 per cent.

Rivet rods were required to endure bending flat upon themselves, closing up completely without showing a sign of fracture when bent cold or after being heated to a cherry red and quenched in water at a temperature of about 70 deg. F.

Rivets were required to be able to withstand being flattened out when hot to a width of 2½ times the diameter of the shank without cracking at the edges.

Rods for screw stay bolts were required to be able to withstand bending when cold through an angle of 180 deg. around an inner radius equal to not more than ½ of the diameter of the rod.

The boiler tubes are of the cold drawn seamless steel type. They were required to be in no part more than 0.01 in. less, nor more than 0.15 in. more than the required thickness; they were required to be circular within 0.02 in., and must not measure more than 1/64 over or under the required diameter. Individual tubes were not permitted to weigh more than 3 per cent less nor more than 5 per cent more than the weight estimated on the assumptions that the tube is the required thickness and that steel weighs 0.283 lb. per cu. in.

Tubes which were found satisfactory in respect to their surface, weight and thickness were separated into lots of 100 or less, and two tubes selected by the inspector at random from each lot and tested:

A section 3 in. long was required to stand being flattened cold its entire length without showing cracks or flaws.

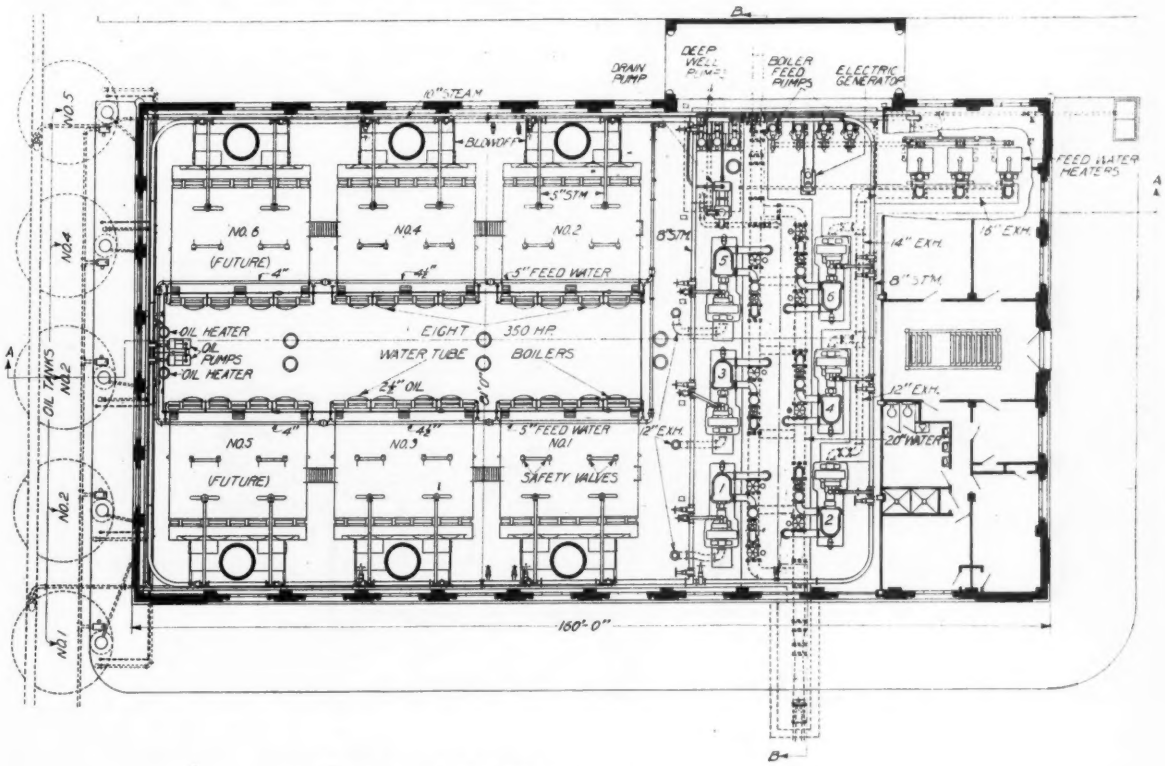


FIG. 3. PLAN OF THE SECOND AND TOWNSEND ST. STATION

Sections 8 in. long were required to stand being expanded, either cold or when heated to a bright cherry red, to 1 1/6 times their original diameter by driving into them a pin having a taper of 1½ in. to the foot without showing cracks or flaws.

Each tube was subjected to an internal pressure of 1000 lb. per square inch.

The common brick was tested as follows:

After immersion for 72 hr., the total absorption of any three bricks having been broken transversely must not exceed 6 per cent of their weight when dried.

Mortar used with common brick was composed of hydrated lime, Portland cement and sand in the proportion of two parts lime, one part cement and six parts sand.

All fire brick were laid in a mortar consisting of

20 per cent pulverized fire brick and 80 per cent fire clay to which had been added not more than 1¼ per cent of hydrated lime.

The boilers are erected in batteries of two. Special care was observed in the design and construction of the furnaces so to arrange them as to permit of fires being lighted under a cold water boiler and steam raised in the shortest possible time without danger of injury to the boilers.

Between the two boilers of a battery there is a brick wall 24 in. thick. The side walls are 8 in. thick, except in the way of the furnace, where they are 13½ in. thick. The front furnace wall is 18 in. thick and the back wall 8 in. thick.

The walls of the furnace are built entirely of fire brick, and the bottoms lined with fire brick, with suitable ducts for the admission of air. The inside of the setting wherever it is subject to contact with hot gases from the furnace is lined with fire brick tied into the walls every fourth course.

All cleaning and explosion doors are hinged at the top and close air tight on faced cast-iron inclined seats.

In order to prevent the infiltration of air through the brickwork and so to reduce the stand-by cost of the boilers to a minimum, the entire setting of each battery of boilers is enclosed in an air-tight steel casing.

At the sides and rear of the boilers this casing consists of galvanized sheet steel plates, held in place by angle bar framing attached to the structural steel supports of the boilers.

Over the top of the boilers are fitted ¼-in. checkered steel plates supported upon angle iron frames. All parts of this casing are attached to the boiler setting in such a manner that they can be readily removed when necessary without injury. The casing is air tight when in place.

The walls where they are exposed to contact with hot gases from the furnace are lined with magnesia blocks 2 in. thick and asbestos board ¼ in. thick, between the brickwork and the steel casing. The tops of

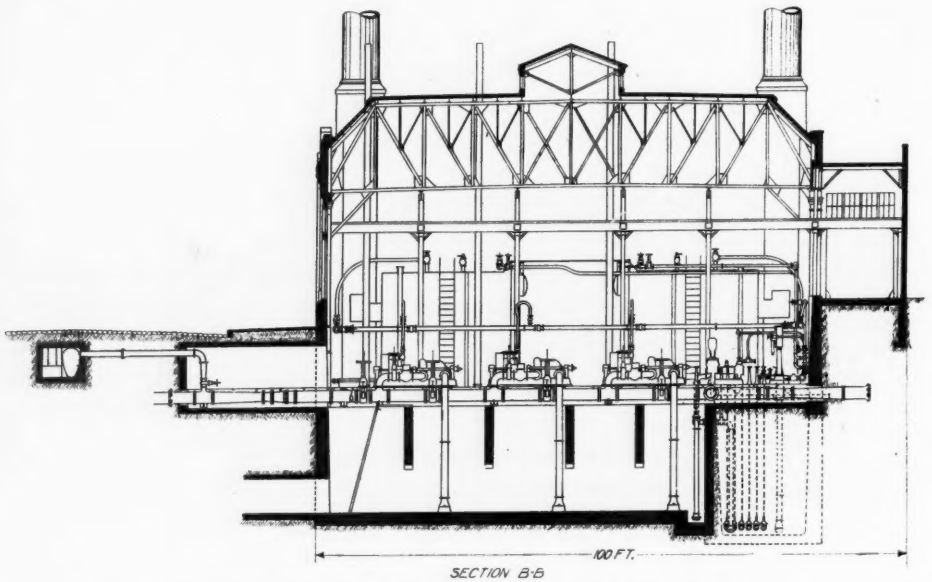


FIG. 4. SECTION OF SECOND AND TOWNSEND ST. STATION

Cast-iron baffle plates ⅜ in. in thickness are fitted between the tubes and lined with fire brick 2 in. thick on the fire side, where necessary, to direct the furnace gases over the entire surface of the tubes.

The fire fronts are of sheet steel 5/16 in. thick, secured to the structural steel framing upon which the boiler is supported and furnished with frames with faced seats for the tube, fire and ashpit doors. The tube doors at each end of the boilers are of pressed steel 3/16 in. thick, with cast-iron frames ½ in. thick. Doors are lined with asbestos board 1 in. thick. The fire and ashpit doors are of cast iron ½ in. thick, and are provided with registers and peep holes.

Cast-iron cleaning doors set in cast-iron frames are fitted in the side walls to provide access to the boilers for cleaning the fire surfaces. In addition, doors arranged to open and thereby prevent injury to the boiler setting in case of the explosion of inflammable gases inside of the furnace, have been fitted in the side walls.

the steam drums are covered with magnesia 4 in. thick, held in place with galvanized wire netting and covered with 15-oz. cotton canvas.

Each boiler is fitted with three oil burners of the size to consume sufficient oil to evaporate 16,500 lb. of steam per hour in each boiler. In addition, each boiler is fitted with a small pilot burner of the same type as the main burner, to be used when the boiler is being held under banked fires.

Each boiler is supplied with the following fittings. All fittings are fitted metal to metal on forged steel pads riveted to the boilers and secured in place with steel studs screwed into the pads on tapered threads.

One 5-in. emergency stop check valve, which serves as the main stop valve, is made with open hearth steel body and bonnet, bronze and seat and rolled Tobin bronze stem with outside screw and yoke. This valve is connected to the steam drum of the boiler with male and female flanges.

The two stop valves of each battery of boilers are fitted with pilot valves and so designed and arranged that in the event of a sudden break in the steam pipe the stop valves will close automatically.

Two 3-in. nickel-plated pop safety valves set to blow at 200 lb. pressure.

One brass rimmed steam gage with 12-in. dial graduated to 400 lb.

One water column fitted with gage glass, three try cocks and independent blowoff pipes from the water column and gage glass. The water gage glass is furnished with extra heavy bronze mountings and with a shutoff device to be operated from the fire room floor. The blowoff pipes from the water column and gage glass are each fitted with a shutoff valve at a convenient height above the fire room floor.

One 2½-in. yoke type flanged composition stop and check valve, attached directly to the head of each steam drum.

One 2½-in. yoke type flanged bronze, 60-deg. valve for the main feed pipe.

Two-and-one-half-inch yoke type flanged bronze blowoff valves are provided for surface and bottom blows.

Each boiler is fitted with a device through which the water in the boiler can be circulated and heated by means of live steam drawn from one of the other boilers in order to accelerate the raising of steam when the boiler is cold and it is desired to put it into service at once.

There are four smokestacks and the foundations prepared for two additional. An umbrella is fitted to each stack above the roof to protect the opening of the roof through which the stack passes.

Each boiler is connected to its smokestack by a flue built up of steel plates 3/16 in. thick, stiffened with angle irons.

In addition to the ordinary damper usually provided with boilers of this type there is provided for each boiler a sliding damper, to close the flue tight when the boiler is not in service.

Boiler Feed Pumps

The main feed pumps are of the vertical single-piston direct-acting type. The steam cylinder of each pump is 12 in. in diameter, the water cylinder 9 in. in diameter and the stroke 24 in. These pumps are so arranged that the pistons and valves of either cylinder may be removed for overhauling or repairs without disturbing the framing of the pumps or the connecting pipes. They were designed for a working pressure of 200 lb. per sq. in., and were tested to a cold water pressure of 500 lb. per sq. in. The steam cylinder wall is 1⅛ in. thick. The cylinder body is clothed with magnesia covering 1⅓ in. thick and lagged with Russia iron.

The pistons of the steam cylinders are of cast iron of the solid type, 4½ in. deep and fitted with two cast-iron snap rings each. Each piston is secured to its respective rod on a well-fitted taper and secured with a wrought-iron nut. Metallic packing is used in the steam piston rods and valve stems. The steam piston rod is of steel 2½ in. in diameter.

The water piston rod is of rolled Tobin bronze of the same diameter as the steam piston rod, and the rods are finished at the ends which fit into the pistons with a taper of 1½ in. to the foot and a screw thread, eight threads to the inch and fitted with a wrought-iron nut.

They are secured together by a cast-steel crosshead, split in a line parallel to the axis of the piston rods and bolted together, into which they are fitted with screw threads, eight threads per inch.

The water cylinder is of cast iron, the thickness of the material in the body of the cylinder being 1¼ in. This cylinder was designed with all surfaces circular in form, so as to insure the greatest possible strength.

A working liner of bronze 7/16 in. in thickness is fitted to each cylinder and secured in place against a shoulder by the stuffing box head, no internal screws

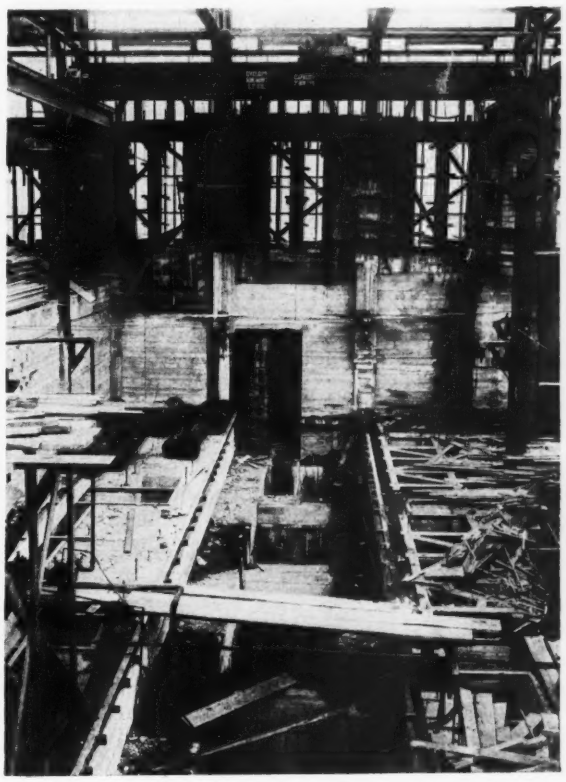


FIG. 5. INTERIOR OF SECOND AND TOWNSEND ST. STATION UNDER CONSTRUCTION

or bolts being used in securing it. The stuffing box head is of cast iron, heavily ribbed and fitted with a bronze throat bushing for the piston rod and with a bronze packing gland secured with three ¾-in. rolled Tobin bronze gland studs. A retaining lip to catch leakage is cast on the stuffing box head and fitted with a drain pipe. The water pistons are of bronze, with bronze follower rings. They are fitted with ebonite packing and are secured to the piston rods in the same manner as the steam pistons.

The suction and discharge valves are of bronze of the wing pattern, and are 2 in. in diameter. Their lift is limited to 3/16 in. They are fitted in heavy bronze valve plates. All valves are fitted with rolled phosphor bronze springs. The valve plates are cast with multiple spider guards held into the body casting and secured

against a shoulder by stout jack bolts, adjusted from the outside.

Each steam cylinder is supported above its water cylinder on four steel distance rods 2¼ in. in diameter, and the valve motion bracket is attached to two of these rods. Each pump is fitted with a large cast-iron air chamber with the discharge pipe cast on the interior extending from near the bottom through the top.

Flanged faces for the connection of steam, exhaust, suction and discharge pipes are fitted to each pump, the diameter of the steam pipe being 2 in., the exhaust 2½ in., the suction 4½ in. and the discharge 4 in.

Features of Deep Well Pump

The deep well pumps are of the vertical single-bucket direct-acting type, having a steam cylinder 10 in. in diameter and a water cylinder 11½ in. in diameter, with a common stroke of 36 in. Each pump is supported upon a cast-iron bed plate resting upon the engine room floor. This bed plate is cored out inside and fitted with a stuffing box on top, through which the plunger works.

The steam cylinder is supported on a cylinder head above the bed plate by two cast-iron columns, one on each end of the bed plates. These columns are cored out inside and fitted to act as air chambers for the pump.

A 12-in. pump column extends through the bed plate and is connected at the bottom end to the pump barrel, which is located with the bottom of the suction strainer, 24 ft. 6 in. below the engine room floor.

Pumps are designed so that the pump column and barrel may be pulled up through the bed plate without disturbing any part of the pump except the steam cylinder and cylinder head, which is arranged to swing around out of the way on one of the columns.

The steam cylinders are of cast iron, the cylinder walls being 1 in. in thickness. These cylinders are designed for a working pressure of 200 lb. per sq. in. and are tested to a cold water pressure of 500 lb. per sq. in.

The pistons of the steam cylinders are of cast iron of the solid type 4½ in. deep and fitted with two cast-iron snap rings each. The steam piston rods are 2¼ in. in diameter. The bucket rod is of rolled Tobin bronze of the same diameter as the piston rod where it passes through the stuffing box in the bed plate. This piston rod is fitted with a bronze differential plunger 8 in. in diameter, for the purpose of equalizing the flow from the pump on the up and down stroke and making it practically a double-acting pump.

The pump barrel is of bronze ½ in. thick and flanged at both ends. This barrel is connected to the bed plates by a piece of 12-in. standard gas pipe peened into cast-iron flanges which are secured at the bottom to the barrel and at the top to a flange on the bed plates. The pump bucket is of bronze 12 in. deep and fitted with four cup leathers, the net area through the bucket valves being 30 sq. in.

The pump bed plate is of cast iron, with passages cored through for the delivery of water on either side. On the top of the bed plate is fitted a bronze stuffing box for the 8-in. plunger with a bronze gland secured by four gland studs.

The two columns on each end of the pump bed plate are of cast iron 7½ in. inside diameter and 50 in. long. They are cored out inside to connect to the cored discharge chambers in the bed plate and serve as air chambers.

The water end of the pump is designed for a working pressure of 100 lb. per sq. in., and was tested to a cold water pressure of 200 lb. to the square inch.

There are two fuel oil pumps of the horizontal duplex piston type. The steam cylinders of each pump are 7½ in. in diameter, the oil cylinders 5 in. in diameter and the stroke is 6 in. The oil cylinders of these pumps are designed for a working pressure of 150 lb. per square inch. The steam cylinders are designed for a working pressure of 200 lb. per sq. in.

The steam cylinders are of cast iron, the cylinder walls being ⅝ in. thick. The steam distribution valves are of the balanced type and are driven through hard composition levers from crossheads on the piston rods. The pistons of the steam cylinders are of cast iron of the solid type and 4½ in. deep, fitted with two cast-iron snap rings each. The piston rods are of cold rolled steel 1¼ in. in diameter. The oil cylinders are of cast iron, the thickness of the material in the body of the cylinders being ½ in. A working liner of bronze 5/16 in. thick was forced into each cylinder and bored after it was in place. The stuffing box heads are of cast iron fitted with bronze throat bushings and turned on the outside diameter so as to serve as a centering piece for the yoke.

The pistons of the oil cylinders are of bronze, with bronze followers, and fitted with cast-iron float rings. The suction and discharge valves are of bronze, with bronze seats screwed into the valve decks on a fine tapered thread. The net area of opening through each set of valves is 6 sq. in., and the lift of the valves does not exceed ¼ in. All valves are fitted with rolled phosphor bronze spring.

The steam and water cylinders are secured together by cast-iron yokes fitted to the heads of each cylinder with male and female joints and secured by bolts. Both pumps are mounted on one cast-iron drip pan, supported upon framing about 30 in. above the floor level. This drip pan is of sufficient size to catch any drips from any part of either pump, and the lip around the outside is of sufficient height to retain within the pan at least four times the volume of one oil cylinder.

There are two tubular oil heaters, located alongside of the fuel oil pumps. Each heater consists of a cylindrical shell with flanged heads and faced joints, having a capacity of 100 gal., into which is fitted a circular copper coil having a surface of 40 sq. ft., through which exhaust steam from the fuel oil pumps can be circulated. The ends of this coil are fitted through packed glands in the heads, so that it may be removed if necessary.

There is one drainage pump of the horizontal duplex piston type, the steam cylinders of which are 14 in. in diameter, the water cylinders 10½ in. in diameter and the stroke of each cylinder is 12 in. The water cylinders are of the balanced type and are actuated by hard

walls of the steam cylinders are 1 in. thick. The steam distribution valves are of the balanced type, driven through hard composition levers from crossheads on the piston rods.

The piston rods are of rolled Tobin bronze and 2½ in. in diameter. Suction and discharge valves are of the best quality of medium rubber 4 in. in diameter, with bronze valve seats screwed into the valve discs on a fine tapered thread. The lift of the valves does not exceed ½ in. Valve stems are of rolled Tobin bronze ¾ in. in diameter, screwed into their seats against shoulders and riveted underneath. The valve guards are of phosphor bronze screwed on to the valve stems against shoulders and fitted with nuts and split pins to prevent them from backing off. All valves are fitted with bronze protection plates 3/16 in. thick, and the full diameter of the valves. They are also fitted with rolled phosphor bronze springs.

The steam and water cylinders are secured to each other by cast-iron yokes which also serve as brackets for carrying the valve motion.

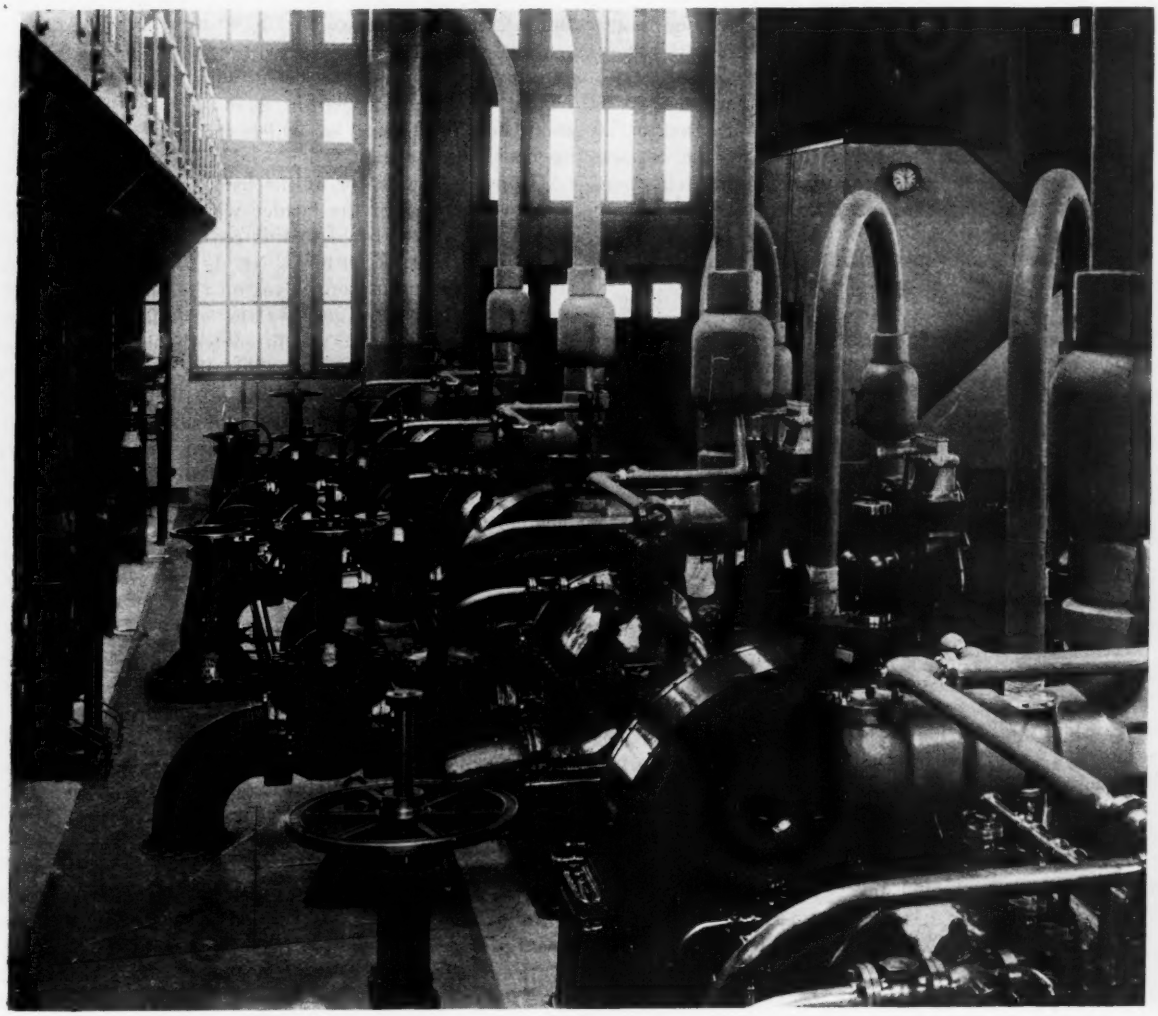


FIG. 6. INTERIOR OF FORT MASON PUMPING STATION

Feed-Water Heaters

There are two 1700-hp. feed-water heaters and filters of the open contact type. Each heater consists of a cast-iron shell, near the top of which is fitted a distributing box, into which flows the cold water entering the heater. From this distributng box the water drops on to a series of inclined trays, arranged one above another, so that the water flowing over the edge of each tray is caught upon the tray next below, until it finally drops from the lowest tray into a filtering chamber at the bottom of the heater. The exhaust steam enters the heater at the side, and passing through an oil separator, circulates around the trays and passes out of the heater and to the atmosphere through the top. All parts are designed to be readily accessible for cleaning or repairs without disturbing any of the pipe connections.

The shell is constructed of cast-iron plates ribbed and bolted together with flanges with rust-calked joints. The capacity of each shell is 240 cu. ft. It is provided

with faces on the inside for the connection of guides for the trays, filter tray, overflow and suction hoods, and with faced flanges on the outside for the connection of cleaning doors and water and exhaust steam pipes.

There is a cast-iron distributing box in the top of each heater, arranged so as to distribute the water evenly over the surface of the heating trays. The heating element consists of a number of cast-iron trays, having a total area of 60 sq. ft., fitted in each heater in five horizontal rows. These trays are supported at a slight angle upon cast-iron guides attached to the shell of the heater. Trays are of a convenient size for handling and are all of the same size and shape so as to be interchangeable. Suitable hinged doors secured with studs are fitted to the shell opposite each end of the trays to facilitate their removal for cleaning.

Cast-iron perforated plates of such size as to be easily handled are fitted about 4 in. above the bottom of the heater shell in each heater and supported upon cast-iron brackets, to form the bottom of the filter chamber. Suitable cleaning doors fitted with faced flanges and secured with nuts are fitted to the heater shell to provide access to the filter chamber. The space above these trays is filled with filtering material.

A cast-iron lip is bolted to the inside of the shell of each heater and extends entirely across one side of the shell at such a height as to leave a space of about 45 cu. ft. between the top of the lip and the filtering trays. An opening in the side of the shell connects to an overflow box fitted with baffle plates in such a manner that any water flowing over the overflow lip will flow out of the heater into the drain pipe, but steam is prevented from escaping into this pipe by a water seal.

A cast-iron hood is fitted over the suction outlet at the side of the heater in such a manner that in order to enter the suction or outlet pipe, anything will be forced to travel down through the filtering tray.

A copper float is fitted in the filtering chamber and connected to a balanced regulating valve in the cold water inlet pipe in such a manner as to shut off this water when the chamber is about to overflow and open it as the water level falls. This float is fitted with a hollow stem and is arranged so that any water leaking into the float will escape to the atmosphere through the stem. A 3-in. blowoff valve is fitted to the bottom of the heater and connected to the drain pipe from the overflow.

Between the inlet for the steam and the water trays is fitted an oil separator consisting of ribbed baffle plates with properly arranged steam passages. This separator is connected to drain into the drain pipes from the overflow.

Current for lighting is obtained from outside sources, but in case the outside source should be cut off, an electric lighting engine has been installed. It consists of a direct-current generator, directly connected to the shaft of a vertical, direct-acting, single-cylinder engine. It is capable of delivering 10 kw. at 110 volts continuously when operating at about 450 r.p.m. under a steam pressure of 90 lb. per sq. in. and exhausting to the atmosphere.

There is a main steam header, 10 in. in diameter which extends entirely around the engine and boiler room and across the main columns between the engine and boiler room. This steam header is supported about 10 ft. above the engine and boiler room floors upon cast-iron brackets secured to the walls and columns of the buildings and set so that it drops about 1½ in. to 100 ft. from the boilers toward the steam turbines.

The header is fitted with cast-iron shoes with planed bottom faces supported upon rollers carried on the planed faces of the brackets which support the header. At or near the middle of each straight run of pipe one of these shoes is securely anchored to the supporting bracket. The other shoes are free to move on their brackets so as to permit of free expansion and contraction of the steam pipe.

The gate valves are set with their stems in a horizontal position and are fitted with chain wheels and chains extending to within 2 ft. 6 in. of the engine room floor, by means of which the gate valves can be operated by one man.

Opposite the center of the back of each boiler there is a tee inserted in the header with a 5-in. outlet, and a 5-in. gate valve fitted to this outlet. The gate valves of the tees back of batteries No. 1, 2, 3 and 4 are connected to the main stop valves on the boilers with 5-in. flanged pipes. The gate valves on the tees back of batteries Nos. 5 and 6 are fitted with blank flanges, as these two batteries will not be installed until some future time.

Five-inch pipes connect the header with the turbines. A steam separator has been installed in each 5-in. branch pipe to the steam turbines near the throttle valve and connected with drain pipes to the feed-water heater.

Two tees have been inserted in the main steam header on the northwestern side of the engine room, near the auxiliary pumps and dynamo. Each of these tees is fitted with a 5-in. flanged outlet to which has been secured a 5-in. flanged gate valve, to which is connected an auxiliary steam header which will be described below. The location of these tees is such that, should it ever be necessary to close down a portion of the main steam header between two adjacent gate valves, at least one of the tees will be outside of the portion of the main steam header which is out of service.

Auxiliary Steam Header

A 5-IN. STEAM HEADER connecting to each of the 5-in. gate valves provided for that purpose on the main steam header has been installed.

Four 2-in. outlets have been provided on this header and fitted with two 2-in. gate valves next to the header. The gate valves of three of these outlets are connected with two 2-in. pipes, one to each of the three main feed pumps, which are installed now with a throttle valve at the pump. The fourth gate valve is fitted with a blank flange on the outlet end for the additional pump which will be installed at some future time as necessity may require.

There is one 3½-in. outlet on the auxiliary steam header fitted with 3½-in. reducing valve, and with a bypass by which steam may be passed around this valve. The reducing valve is adjusted to reduce the steam pressure to about 100 lb. to the sq. in. Branches are led from the low-pressure side of this reducing valve

to connect to each of the deep well pumps, to the drainage pump and to the dynamo, with a throttle valve at each steam cylinder. An outlet has been provided and covered with a blank flange to which the additional deep well pump which is to be installed at a later date can be connected.

The branch pipes which will be connected to steam turbines Nos. 5 and 6, to feed pump No. 4 and to deep well pump No. 3, which are to be installed at some future time, are not installed at the present time, but all the fittings to which these pipes are eventually to be connected have been installed in the main steam pipe.

The exhaust pipes from steam turbines Nos. 2 and 4 are fitted with 12-in. iron body, bronze mounted, flanged atmospheric free exhaust valves. All the direct-acting pumps except the fuel oil pumps and the electric light engine are connected to exhaust through the feed water heaters and are fitted with shutoff valve at each steam cylinder. All exhaust pipes are fitted with drains discharging into the sump from which the deep well pumps draw.

The fuel oil pumps are connected so that they may exhaust through either the oil heater or directly to the atmosphere as desired.

The deep well pumps draw from a sump directly under the pumps and discharge through a 6-in. pipe into the fresh water tank. This discharge pipe is fitted with a separate shutoff gate valve at each pump. An overflow from the fresh water tank is fitted to discharge back into the sump. A 6-in. flanged fitting is fitted into the bottom of the fresh water tank, to which is attached a 6-in. gate valve, and leading therefrom is a 6-in. pipe which is connected to each feed-water heater with a shutoff gate valve in each flange. A 4-in. flanged composition, yoke type, 60-deg. globe valve is fitted on the discharge side of each feed pump and connected to a 5-in. feed pipe. This 5-in. pipe is led over the tops of the boilers in a double loop, so that an accident to no part of the pipe can make it necessary to shut down the entire plant.

There are two 3½-in. extra heavy pipes installed back of the boilers and connected to an 18-in. sewer. From the 2-in. auxiliary steam valve on each boiler a branch is led to a steam pipe extending over the tops of all the boilers and over the fuel oil pumps. This pipe is fitted with branch pipes to each fuel oil pump with a throttle valve at the pump and with branch pipes to the oil burners of each boiler. Gate valves are inserted in this pipe between each battery of boilers and between the batteries Nos. 5 and 6 and the fuel oil pumps, so that any portion of the pipe may be shut off for repairs.

A pump regulator is installed in the steam pipe to each fuel oil pump and connected to the discharge pipe of the pumps in such a manner that as the pressure on the discharge side of the pump increases a throttle valve on the steam pipe will be closed, and as the pressure falls this throttle valve will be opened.

There are five fuel oil tanks, located under the roadway in Stanford street. From each of these tanks there is a 4-in. pipe led into the building, terminating in a flange just inside the building wall. There is also a 2-in. pipe leading from each of the tanks in the same manner. Immediately inside of the building each 4-in. pipe is fitted with a gate valve and connected to a 4-in. suction manifold located near the fed pumps. This suction manifold is connected by means of 4-in. pipe to each of the fuel oil pumps. Strainers of the self-cleansing type are fitted in each of the suction pipes.

Each fuel oil pump is connected to discharge through a 2½-in. pipe to the heater or to the fuel oil header described below, with suitable shutoff valves A 2½-in. fuel oil header is run over the tops of the boilers, with a branch to the oil burners of each battery and a separate shutoff valve in each branch.

A 2-in. relief valve is installed on the discharge pipe from the fuel oil pumps near the pumps and connecting with a 2-in. pipe, which in turn is connected to each of the 2-in. pipes above mentioned, from the top of the oil tank, with a gate valve in each pipe. The arrangement of the relief valve and of the discharge pipes back to the tank is such that when a fuel oil pump is drawing oil from one tank the oil may be discharged through either fuel oil heater and the fuel oil header, clear

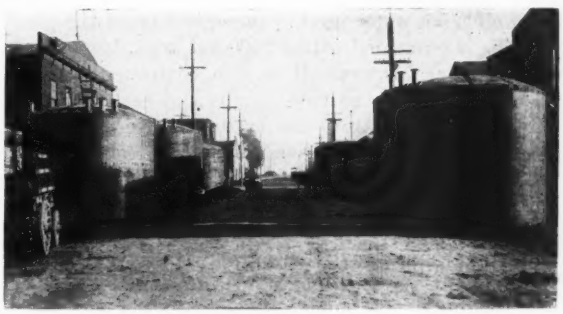


FIG. 7. OIL TANKS FOR PUMPING STATION

around this header, through the relief valve, back to the tank from which it was drawn.

PIPES FOR MULTI-STAGE TURBINE PUMPS

A 12-IN. CAST-IRON pipe with a bell-mouthed inlet is connected to the suction flange of each multi-stage turbine pump. These suction pipes are fitted with eye bolts so that they may be readily removed by means of the traveling crane, in the event of their requiring repairs or renewal.

Each pump discharges through a 12-in. elbow, a 12-in. check valve, a 12-in. gate valve and another 12-in. elbow, into a 20-in. main.

There is a Venturi meter near each end of the 20-in. main. These meters are made of cast iron with bronze throat chambers and proportioned to withstand the full working pressure of 325 lb. per sq. in., whether water is flowing through them or in a quiescent state. A combination indicator and chart recorder for each meter is set up in the engine room. The escapement of the clock which drives each recorder is connected to and operated from a master clock.

The meter on the Second St. side of the pumping station is fitted with a tee, to which is connected a 12-in. gate valve and pipe through which water may be discharged into the Second St. sewer. A cast-iron diffusion chamber is fitted in this sewer to destroy the velocity in the water discharged from the above pipe, so that the pumps may be operated or tested without discharging into the high pressure pipe system.

Each turbine pump is fitted with a 2-in. flanged composition globe valve on top of the pump casing for flushing the pumps with fresh water, and each pump is equipped with a 1½-in. flanged nozzle, to which is fitted a 1½-in. relief valve. This relief valve is made with an adjustable spring so arranged that the pressure at which it opens may be varied from 150 to 350 lb. per sq. in. by means of a hand wheel.

A grizzly or strainer is installed in the sump for the suction of the turbine pumps. The grizzly is made of ½-in. by 1½-in. grizzly bars, spaced 3 in. apart and secured with bolts and separators. The grizzly is arranged so that it can be removed by means of the traveling crane over the engine. A rake is provided by which seaweed or oeher matter accumulating on the face of the grizzly can be removed.

There is a 5-in. wrought-iron pipe terminating just inside the wall on the Second St. side of the building, in a standard flange, 10 in. in diameter and connected to the mains of the Spring Valley Water Co., for supplying all fresh water used in the operation of the plant. This pipe is connected with a 2000-gal. tank, located over the feed-water heaters. It is also connected with the feed-water heaters, the feed pumps and each of the six fresh water tanks, which are located under the floor of the boiler room. One million gallons of fresh water are stored under the boiler room for supplying the boilers with fresh water in case the Spring Valley water mains should be broken, or service discontinued for any reason. The storage capacity of fuel oil and fresh water is such that the plant can continue in operation for 96 hr. without receiving any supplies from outside sources.

The plant is earthquake proof, fireproof and the roof is designed to withstand the impact of falling chimneys. The building is of steel frame and reinforced concrete construction.

A GOOD MANY of the disabled soldiers now being vocationally re-educated by the Federal Board are taking courses of training somewhat out of the ordinary, and the list of those who are undergoing re-education April 1 reveals some interesting sidelights on the desires and ambitions of the young men of the country.

Two are studying air-brake operation; three are taking bee culture; nine have entered barber colleges. It would not be supposed that boiler making was the sort of light work the disabled man would select but three students have elected that. Twenty-six are taking carpentry and two biology. Dentistry is fairly popular, as there are 31 students in that, while two are studying "edge trimming," and 11 of them are studying embalming. Forestry has attracted 18, while two are taking special courses in geometry. Jewelry and watch repairing have attracted 26, and 13 are embarking upon the uncertainty of journalism. Owing to impaired hearing on account of the tremendous din of artillery fire, 23 men are studying lip reading. One is taking massage, 20 have gone in for oxy-acetylene welding. Three men are studying vocal music, two are studying violin and fourteen, various other instruments. Eleven are studying theology; five window trimming, and seven are preparing to be veterinary surgeons. Landscape gardening is being taken by nine; sign painting by 12; pharmacy by 24.

Boiler Fuel Economy

By Mark Meredith

FROM the average figures obtained from tests of two hundred and fifty typical steam boiler plants, interesting data regarding the economy effected by the adoption of scientific methods in the boiler house have been obtained. Of the plants referred to, only two gave efficiencies of over 80 per cent, nine gave efficiencies from 75 to 80 per cent, thirteen showed 70 to 75 per cent, thirty gave 65 to 70 per cent, forty-four gave 60 to 65 per cent, sixty-two gave 55 to 60 per cent, forty-seven gave 50 to 55 per cent, while forty-three gave less than 50 per cent. The average working efficiency for two hundred and fifty was, therefore, 60.09 per cent; and, while 61 per cent of the plants were working with an efficiency of less than 60 per cent, only 9.6 per cent of the plants exceeded 70 per cent efficiency. Again, seventy-five colliery steam boiler plants gave an efficiency of only 51.2 per cent as compared with the average of 60 per cent for the whole country.

For the purpose of making a calculation as to the possible saving of fuel by increased efficiency of the whole of the country's steam-raising plants, the average figure of the two hundred and fifty plants investigated is taken as typical for all the plants of the country. According to the recent report of the Coal Conservation Sub-Committee of the Reconstruction Committee of Great Britain about 80,000,000 tons of coal are used annually for power production only. Deducting 15,000,000 tons used on railways, 65,000,000 tons remain, of which 90 per cent or 58,500,000 tons are used for power production by steam raising. In many industries, however, much more steam is used for heating and general technical processes than for power production. It is, therefore, taken that the amount of coal used for steam generation in the United Kingdom is between 75,000,000 and 100,000,000 tons. If, then, the efficiency of the two hundred and fifty plants tested, consisting of one thousand boilers, is 60.09 per cent, and the annual coal consumption 2,166,000 tons, an increase in efficiency to 75 per cent represents a saving of 430,000 tons. A similar increase in efficiency of the whole of the country's boiler plants would represent a saving of 20 per cent of fuel, or of 15,000,000 to 20,000,000 tons. Of the 287,000,000 tons of coal raised during 1914, 20,000,000 tons were consumed by the collieries themselves. Practically the whole of this coal provided steam for power to raise the coal. This represents 7 per cent of the total output. If these colliery plants were reorganized to run at 60.09 per cent efficiency (the average for the country) a saving of 15 per cent, or 3,000,000 tons, would be effected. Run on scientific lines to yield 70 per cent, then a 27 per cent saving, or 5,400,000 tons a year would result.

The question of coal economy being important as part of a national scheme of reorganization, essential to future progress, a plea is made for the quick survey by experts of all the boiler plants of the country, and the immediate reorganization of the largest and most inefficient plants, and those plants, too, which will always require to produce a large amount of steam for purposes other than power production, such reorganization fitting in with the future scheme of coal economy.

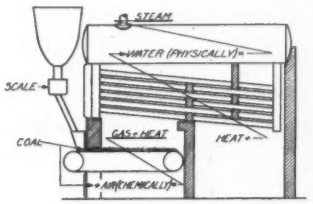
FUEL CONSERVATION LETTERS

By Joseph Harrington, Formerly Administrative Engineer for the State of Illinois

Coal Weighing. Letter No. 11

THE importance of coal weighing cannot be overstated. Remember, you are collectively handling a product every year that mounts up in value to millions of dollars.

In most cases, the cost of your coal is one of the largest items entering into the cost of the finished product of your plant; and in all cases, it is the largest single item entering into the cost of steam or electricity.



The burning of coal is, and should be, considered a refined chemical process. The fact that it is done on such a large scale does not affect the situation.

We shall never again see the days of cheap coal. So let us get ready now to account properly for the use of the most valuable single commodity handled by man.

You may consider that your boiler plant as a whole is the smallest unit; but it is not so. The individual boiler is the unit which we must consider in this matter. No two boilers are just alike in their operation or results. The efficiency of steam generation is a matter of individual boiler and furnace efficiency. Plant efficiency is directly dependent on this unit efficiency.

Let us look at the matter, therefore, in this light and see what is necessary for proper accounting of your heat units.

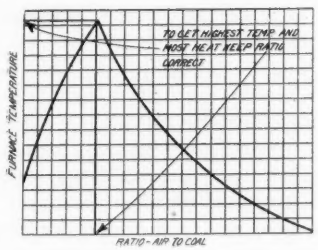
If you were manufacturing any one of a thousand commercial products which are the result of chemical reactions, you would not dream of throwing the ingredients together in a haphazard manner, but would most carefully weigh each and every constituent entering into the combination. So must you consider the production of steam.

Steam, or its equivalent in heat, however, is merely a by-product of the chemical reaction that goes on in your furnace. The primary product is carbon dioxide, or CO_2. The amount of CO_2 developed is, therefore, a measure of the efficiency of this reaction. This will be gone into in detail in my letter on gas analysis.

Those who manufacture steam on a large scale know full well the importance of keeping accurate records. In the large central station this is, as a rule, being recognized; and the latest and most up-to-date plants are equipped with automatic coal scales which weigh the coal as it passes from the overhead bunker to the stoker hopper. It is the small, hand-fired power plant, however, that is woefully deficient in this particular matter, and yet it is a thing entirely practical.

If the importance of coal weights were understood as well as the importance of keeping any accurate account of your bank balance is understood, ways and means would be very promptly developed for securing the result.

You insist upon your bookkeeper sitting up nights to locate an error of a few cents in his accounts, but you do not worry about your fireman wasting a few tons of coal and having a shortage in **his** accounts of many dollars. How utterly inconsistent is this policy!



Many times you will hear the argument advanced that "it does not pay to weigh the coal to each boiler." Then I say to you, "It does not pay for you to keep accurate records of your sales to your various customers." You can lose about as much one way as the other.

After all, the ultimate aim and object of our entire campaign for increased efficiency is to increase the ratio between the water evaporated and the coal fired. This ratio (generally expressed by the phrase "water evaporated per pound of coal") is the result of a large number of conditions, each one of which must be right in order to have a right result.

It is impossible for you to determine directly this condition, unless you weigh your coal to each and every boiler in your plant, and weigh the steam coming therefrom.

Many ways exist by which this can be done, which would make the story too long even to be referred to in this letter. Investigation, however, will enable you to determine practical ways and means of accomplishing this result. It is sufficient for me here merely to emphasize the necessity of accurate coal weights.

Let us never again go back to the old haphazard way of buying another car of coal when the first one is gone, without knowing where the first one has gone.

Setting Valves of Corliss Engines

PLAIN AND UNDERSTANDABLE INSTRUCTIONS IN SETTING SINGLE AND DOUBLE ECCENTRIC VALVE GEARS OF DIFFERENT TYPES. BY A. G. SOLOMON

MANY articles are published giving details of how to set the valves and eccentrics of Corliss engines. All engineering text-books devote at least a chapter to this important subject. These articles in the technical magazines and the instructions given in the text-books are, as a rule, very misleading if followed too closely.

Whenever the subject of setting Corliss valves and eccentrics is dealt with, the type of engine and the style of the valve should be mentioned. There are several types of Corliss valves and valve motions, and the general directions for valve setting will not apply to all types.

Most instructions take into consideration only what we may term the common or simple Corliss engine, which will include engines having one eccentric which operates the four valves of one steam cylinder by the motion imparted to one wristplate. The only chance of misunderstanding that may occur with the valve setting of a single eccentric Corliss is where the motion is what is called indirect. Indirect motion is found on very few

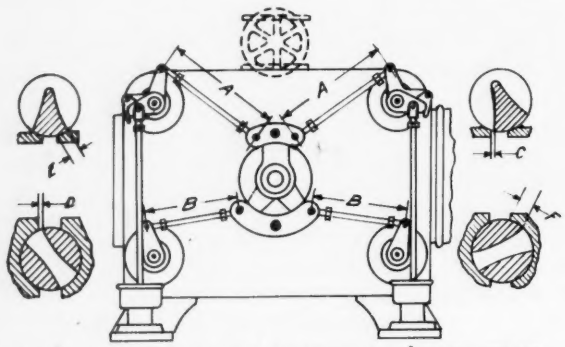


FIG. 1. VALVE GEAR SIDE OF MURRAY CORLISS STEAM CYLINDER

single eccentric engines and is readily noticed, as the reach rod from the rocker arm to the wristplate is connected to the exhaust side of the wristplate instead of to the side connecting with the steam or admission valves. This indirect motion is found on some of the older types of upright steam cylinders. The valve setting will be the same as for the direct motion, but the eccentric will follow the crank instead of lead it.

The general rules for setting the valves of the single eccentric Corliss are so well known that this article will only touch on the subject enough to bring out the peculiarities of the double eccentric type more plainly.

The first move in setting Corliss valves is to center the valve motion. The complete valve motion consists of the eccentrics, rocker arms and the wristplates.

Begin at the eccentric and place the heavy side directly plumb over the center of the engine shaft. For the present, do not pay any attention to the position of the crank. Next use a plumb line at the rocker arm, and see that it is perfectly central and that the line cuts down through the center of both pins. Make any necessary adjustments by lengthening or shortening the rod extending between the eccentric and rocker arm. Now move to the wristplate and again use the plumb line. There should be marks on the wristplate and hub to show the central position; but even if the marks are found, it is best to check up with the plumb line. Place wristplate in its central position by changing the length of the reach rod if necessary. The valve bonnets or plates at the ends of the valve chambers are now removed and the shop marks located. At this point it is always best to pull out all four valves and use a steel scale to see that the marks are true with the steam edge of both valves and port openings. After verifying the marks, the valves are replaced and the engaging hooks examined to see that the valves are hooked up in the central position.

Now we come to lap and lead. Lap is the amount of closure or distance that the steam edge of the valve overlaps the port; or, plainly, it is the amount that the valve is closed. Lead is the opposite term to lap, and means the amount of opening of a valve. With the wristplate central, the steam or admission valves should have from 3/16, to 3/8-in. lap, according to the size of the steam cylinder, the 3/16 being for engines of cylinder diameter of 10 in. or less and the 3/8 for larger sizes. The lap of the exhaust valves will depend on the size of the engine, load conditions and the pressure against which the engine exhausts.

For ordinary operation the exhaust valves are given from 1/16 to 3/16 in. lap when the wristplate is central. The valve gear should be carefully keyed up before any attempt is made to set the valves, as lost motion will cause error. Next place engine crank on the center toward the steam cylinder. Loosen the eccentric and move it in the direction in which the engine runs till the head end steam valve shows the proper lead. The lead will be from 1/32 to 3/32 in., depending on the diameter of the cylinder.

Fasten the eccentric and move the engine over till the crank is on the other center. See that the steam valve on the frame end of the cylinder has the same lead as the one on the head end.

After the rod between the eccentric and the rocker arm, and the rod between the rocker arm and the wristplate have been adjusted to plumb the rocker arm and wristplate, they must not be changed.

If the steam and exhaust valves cannot be set exactly by means of the radial rods, the key holding the valve stem to the bell crank must be moved. A valve stem can easily be twisted while an engine is in operation, and the defect may not be noticed till the shop marks are examined or an indicator diagram taken.

After the valves have been set to have the proper lap with the wristplate central, it is noticed that the eccentric is advanced to give the steam valves the proper lead. With the engine crank on the center and also the wristplate central, the heavy side of the eccentric will be exactly 90 deg. ahead of the crank. Advancing the eccentric will cause its relation to the crank to exceed 90 deg. by the amount necessary to give the steam valves lead. Then on a Corliss engine having one wrist-

plate which operates all four valves the eccentric is always 90 deg. plus the angle of advance ahead of the crank. (Note.—The exception to this rule is found when the reach rod is connected below the center or hub of the wristplate, giving indirect motion to the steam valves. In such case the eccentric follows the crank 90 deg. minus the angle of advance.)

Now keep this point in mind: In valve setting on the single eccentric Corliss engine it is always true that the wristplate reaches its central position before the crank reaches its center.

After the eccentric has been set and fastened the engine should be rolled over a complete revolution and the marks at the ends of the valves watched. See that the admission valves have the proper opening as the crank passes both centers, and notice how far the crank has traveled when the steam port into the cylinder is wide open. Notice the motion of the exhaust valves and pay particular attention to the position of the crosshead at the time the exhaust valve just closes. In ordinary practice and with regular load conditions the crosshead will be about 4 in. from the end of travel when the exhaust valve is just closed. This will imprison steam in the cylinder and give the engine what is known as compression.

By the foregoing explanations it is plainly seen that setting the valves of a single eccentric Corliss engine is a very simple matter. If the engine is either cross or tandem compound, the valve setting is the same for both high and low pressure cylinders.

Corliss engines of the double eccentric type are constructed to give proper regulation for extreme variation in load conditions. One eccentric operates the admission valves and the other the exhaust. This arrangement makes possible great economy in steam consumption. The full volume of steam is admitted to the cylinder almost at the instant that the crank passes the center.

Corliss engines which have all four valves operated by one wristplate cannot be set so as to have cutoff occur later than ¼ stroke; but where there is one eccentric operating the admission valves only, it is possible to have cutoff at ¾ stroke.

If we study the eccentric a little we shall see that the fastest motion is imparted to the wristplate while the heavy side of the eccentric is traveling over its vertical position; that is, the valves are moved farther and quicker during this part of the eccentric travel. As this is true, the object aimed at is to have the valves and eccentric set in such a manner that the steam valves are opened wide as quickly as possible after the crank has passed the center. To obtain this quick opening, the wristplate must come to its center of travel after the crank has reached its center. This statement cannot be true where only one eccentric is used, as the exhaust valves could not be adjusted correctly; but when we can set the exhaust valves independently of the admission valves the eccentric operating the admission valves can be set so that it leads the crank less than 90 deg. This will allow the admission valve to come to its full opening in the shortest possible time.

Figure 1 shows a common form of wristplate connections where two eccentrics are used.

To set the admission valves we proceed, at the beginning, exactly as if we were considering a single eccentric engine; that is, we plumb the eccentric so that the heavy side is directly upright over the shaft center. Then the rocker arm and wristplate are centered.

Now we come to the difference found in the setting of valves on the double eccentric engine when compared with the single eccentric type. Instead of the admission valves having lap when the wristplate is central, they will have lead or opening. This will not look unreasonable when we remember that on this type of engine the wristplate center follows the engine center.

Now, with the back bonnets removed and the shop marks located properly, the steam valves are set to have from ⅛ to ⅜ in. opening, depending on the size of the cylinder. (This amount of opening does not refer to valves of the double ported type but only to single port.) The engine crank is next placed on the center and the eccentric moved back toward the crank till the steam valve shows an opening of 1/16 in. Roll the engine over to the other center and see that the other valve has the same opening.

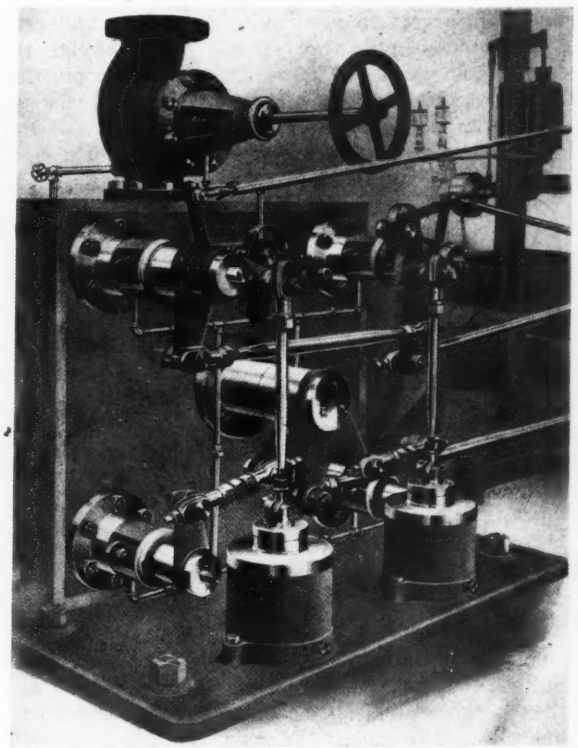


FIG. 2. VALVE GEAR SIDE OF DE LA VERGNE STEAM CYLINDER

The exhaust valves are set the same as on any single eccentric Corliss engine, only it must be remembered that the motion is imparted from the eccentric to the bottom of the exhaust valve wristplate. This gives an indirect motion, and the eccentric will be directly opposite where it would be if the motion were imparted to a point above the wristplate hub.

There are many different styles of Corliss valve gear, and the setting of the valves will depend somewhat on the way in which the motion is imparted to the valves. By this is meant the leverage exerted from one moving

part to another. So after the valves have been adjusted carefully so that the shop marks show properly, the final and exact adjustment must be made by using an indicator.

Figure 2 shows a Corliss valve gear where there is but one wristplate. This wristplate operates the exhaust valves only. The admission valves are operated by rods direct from the eccentric and rocker arm. This style of valve gear is found on engines of late design and is so arranged that the quickest possible steam admission is obtainable. The range of cutoff is long in the extreme to suit any changing load conditions. As a rule, double-ported valves are used in engines having this long range cutoff valve gear.

In setting the steam valves, the eccentric is first set with the heavy side plumb. The rocker arm is then brought to a vertical position by adjusting the length of the eccentric rod. Next plumb down through the center of the crank end valve stem so that the pin that connects the reach rod from the rocker arm to the steam valve lever is central to the valve stem. Make this adjustment with the reach rod. Then plumb the lever

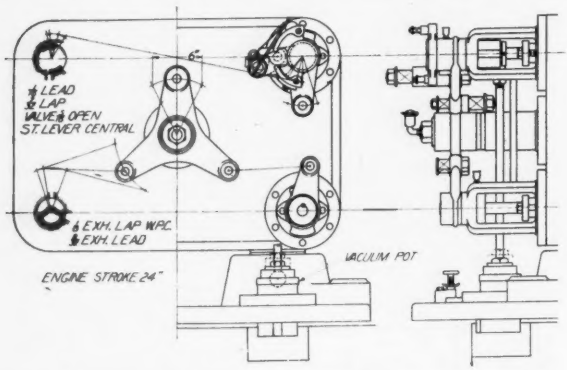


FIG. 3. DETAILS OF VALVE SETTING OF THE PRESCOTT PUMP

of the head end steam valve so that the valve stem and lever pin are vertical. This last adjustment is made with the rod connecting the valve levers. The distance between the centers of the valve stems and the lever pins will now be exactly the same.

Now with everything central or vertical, and both valves hooked up, the shop marks on the ends of the valves should show both valves to be open from ¼ to 9/16 in., depending on the diameter of the cylinder. The only way to change the amount of opening is to cut new keyways in the valve stems. In case of a twisted valve stem or the installation of new valves or valve stems, the greatest possible care must be exercised to make the keyways right.

Next place the engine crank on the crank end center and move the eccentric till the crank end valve has a lead or opening of 1/16 in. Moving the eccentric is a different process from that of engines having other style valve gear.

As the steam valves have greater opening when in mid position than when the crank is on center, it is readily seen that the valve gear central position must follow the engine center. As this is true, the eccentric must be less than 90 deg. ahead of the crank. At this point the eccentric imparts the fastest motion to the valves and the distance back from 90 deg. will be but little. Move the eccentric back toward the crank slowly and fasten it when the valve shows 1/16 in. opening. Roll the engine over to the head end center, and see that the head end steam valve has also 1/16 in. lead.

As both valves are open when hooked up and in a central position, it is very necessary that cutoff take place before the engine comes to the center. Never allow the valves to carry full stroke, as is customary with other types of Corliss engines. The exact and equal points of cutoff must be made by taking diagrams with an indicator.

In setting the exhaust valves, the eccentric rocker arm and wristplate are all set plumb in a vertical position. Then adjust radial rods so that both exhaust valves show ⅛ in. lap. Now place crank on crank end center and move the eccentric so that the head end exhaust valve will be open about 3/16 in. Roll the engine to the other center and see that the crank end exhaust valve has the same opening. This eccentric follows the crank, as the motion is imparted to the valves by the reach rod being connected to the wristplate below the wristplate hub.

Corliss engines of the same general design as the one just explained, but having single-ported instead of double-ported valves, have some slight difference in valve setting. With the eccentric, rocker arm and valve levers plumb, the admission valves will have lead or opening equal to about 1/3 of the width of the port that leads into the cylinder.

THE LAW creating the Federal Board for Vocational Education made it the duty of the Federal Board to undertake the placement of wounded and disabled soldiers, sailors, and marines. Many of these men while suffering some slight injury, not enough to require a course of retraining but sufficient to prove a serious handicap in their former occupation, are in need of expert advice upon the best method of proceeding in order to utilize their unimpaired abilities, and this the Federal Board is prepared to furnish, and has been furnishing. Since the Board began dealing with the soldier, 3904 cases have been placed in suitable employment. The Federal Board maintains a placement division which keeps a check on the number of men in training, the probable length of time required for each man to finish his course, the date at which he will probably be ready to take employment; and, meanwhile, the placement officials are conducting a search for suitable employment for these retrained men, with the result that as each man finishes his training, if it is a wage earning occupation, there is a job ready for him. He is placed in the job, supervised by the Federal Board, his training allowance being continued, as well as the support allowance to his dependents, until he demonstrates that he can "carry on" under commercial conditions. When he is employed as a competent worker and placed upon the pay roll, his support allowance ceases; but the compensation from the War Risk Insurance Bureau then automatically begins, provided he has a permanent disability, and supplements his earning in the line for which he has been retrained.

THE MEN who do things, and not the men who merely talk about things, are those who bless the world.

SAMUEL INSULL

ONCE EDISON'S PRIVATE SECRETARY, HIS RISE IS A STORY OF AMBITIONS REALIZED. NOW DIRECTING GENIUS OF A SCORE OF LARGE INTERESTS. BY PAUL CRISSEY

OUT in Lake County, Illinois, well within motoring distance from Chicago, is a farm of broad acres, myriads of modern buildings and a palatial home. Passing tourists slow down their machines as they pass the white fence and feast their eyes on the beauty and orderliness of the scene. On Sunday mornings the fortunate ones on the broad highway ofttimes see a big, rugged man wandering dreamily out past the barns to a distant corner of some far pasture where sleek cattle raise their heads and sniff in friendly fashion at his approach.

In his hands this man carries two pails filled with salt, which he distributes systematically among the various herds in the fields. It is a ceremony performed as religiously and as conscientiously as a ritual, and lucky indeed is the guest at the big farmhouse who is invited to accompany his host and the salt pails on these Sunday visits. For then, as never any other way, does the guest receive a cross-sectional view of Mr. Insull's personality.

SAMUEL INSULL

For the farmer is Samuel Insull, engineer, millionaire, directing genius of a score of interests of such enormous proportions that their capital runs into the hundreds of millions of dollars, and last but not least, Samuel Insull, a hero-worshipper.

Mr. Insull's life is a story of achievement. But his successes may be traced almost directly to the day when, as a slim, earnest boy in London, he first heard of Thomas A. Edison, and in a youthful but determined way resolved that some day he would work with the master inventor. His dreams, conceived in the fogs of London, became the incentive which carried him over innumerable obstacles and eventually placed him in the position which he occupies today.

The bare facts of Mr. Insull's existence may be told in a breath. The story of his rise is a romance so closely allied with the development of American industry and engineering progress that it must necessarily be included in the history of the latter as a vital factor toward its achievement.

Samuel Insull was born in London, England, on Nov. 11, 1859. He began his business career as an office boy at $1.25 a week, meanwhile studying shorthand, in which he soon became quite proficient. Some trick of fate brought to him the interesting story of Edison in far-off America and his wonderful experiments in electricity. It captivated the boy, for coupled with an almost uncanny vision of the possibilities which lay in the development of electricity, Insull also was possessed of an imagination. Edison became his hero. He studied voraciously and kept pace with new developments. Eventually, when he was 21 yr. old, he accepted a position as secretary to Col. George E. Gouraud, who was Edison's English representative.

Then came an eventful day when Edison sent for him to be his private secretary. He landed in America on Feb. 28, 1881, and went directly to Mr. Edison's office at 65 Fifth Avenue. It is just possible that both the inventor and his new secretary were slightly disappointed in each other, for Mr. Insull had created an image of his own which he called "Edison." At any rate, the new secretary began almost immediately to learn one of the greatest lessons of his life. For right at the outset of his connection with his new employer he learned of Edison's great contempt for the clock. This contempt, through years of association with the master electrician, is responsible in no small measure for Mr. Insull's own success.

"It is not possible for all engineers to get to the top," said Mr. Insull in an address some time ago. "It is not possible for you all to become Edisons. But it is possible for you to follow out the general scheme, to have the same ambitions, to have the same power of continuously sticking at a thing that Mr. Edison himself has.

"I remember once sitting in his laboratory, at a time when I was his private secretary, when a gentleman called on him and introduced his son and said: 'Mr. Edison, I wish you would give my son some motto to remember.' And in a flash Mr. Edison turned to the young man: 'Young man, never look at the clock.' "

It was at this time that Mr. Edison had first obtained successful results using a carbon-filament lamp, which was a marked improvement to the paper-filament lamp then more or less familiar in England. Mr. Insull wrote long letters to his friends in London, describing this achievement and predicting a new future for electric lighting. But the early days with Edison were not all marked by success, neither did the young secretary find his lot a bed of roses, nor his work clearly defined. He did anything and everything, even to purchasing Mr. Edison's clothes, and then came the dark days when, at an extremely crucial period in the inventor's work, the lack of money threatened to jeopardize all of his labors.

There is no question but that Samuel Insull pulled Edison through to success by raising funds which made a continuance of his work possible. The secretary even borrowed money for their meals at times during these dark days, and in almost no time he became the inventor's financial man. Aid was obtained from J. P. Morgan and Henry Villard, and Insull soon acquired a genius for raising funds.

About this time labor troubles in their own machine shop made it advisable for them to build a plant at Schenectady, N. Y., and Samuel Insull became general manager. He built the plant from a shop employing 250 men to one employing 6000, and it was this factory which became later the nucleus for the General Electric Co.

By this time Mr. Insull had gained a practical working knowledge of every phase of the business and had developed a remarkable ability to handle men. Also, though far from unimportant, Mr. Insull possessed the faculty for remembering details.

"Don't carry a notebook," he advises. "The man who takes an interest in his business usually has no trouble to remember the main facts connected with it. Exercise your memory."

Along in 1889 Mr. Insull's imagination, which as a boy visualized a great future wherein business efficiency and economy could be consolidated with engineering genius to render true service to the public, took definite form, and as a result of his plans the various Edison manufacturing companies and the Edison Light Co. consolidated into the Edison General Electric Co., with Samuel Insull as vice-president in charge of the entire manufacturing and selling ends of the business. In 1892 another consolidation was effected, bringing in the Thomson-Houston Co. under the name of the present General Electric Co.

Here begins the stage in his life when Mr. Insull's own individuality began to receive recognition aside from his connection with Mr. Edison, for in the fall of 1892 he dropped out of the General Electric Co. and became president of the Chicago Edison Co., where, for the first time, he had a clear field to put into operation the ideals which have led to the development today of the greatest public service corporation in the world, and ideals which have revolutionized the electric power plant industry.

His experience with the great inventor had given him a clear insight, not only into the technical side of engineering, but into the varied phases of business which the modern engineer who attempts big projects must know today to achieve success. He had learned electric lighting from the manufacturing of the materials to the producing of the current; he had handled big financial problems, and with this foundation he had outlined a clean-cut, definite plan for serving the public with power and light—a plan which today has revolutionized the methods by which public service corporations meet and treat with the public which they serve.

At that time the Chicago Edison Co. had a working capital of only $883,000 and a capacity of about 4000 hp. Its policies were uncertain, its patronage uncertain and its competitors as thick as flies. Today, under the guidance of Mr. Insull, the old company, now known as the Commonwealth Edison Co., has actual assets well in excess of $85,000,000. It has a capacity of more than half a million horsepower and uses more than 300 tons of coal an hour.

But his achievement with the Edison Co. in Chicago is only part of the story of Mr. Insull's activities. The formation of the Middle West Utilities Co. and numerous other organizations created, consolidated and controlled by him, followed swiftly, until today the total revenues of his various concerns is said to be in excess of $100,000,000 a year on a total investment in excess of $450,000,000.

During the construction days, when one by one the Insull interests were consolidated, the dead wood lopped out and the leaks stopped, Mr. Insull never hesitated to throw out valuable machinery if some new and practical device could be installed to give greater efficiency or greater economy.

In this happy combination of fundamental knowledge, the technical, the financial, the ability to handle men and to serve the public really lies the secret of Mr. Insull's marked success. The idea which he has constantly borne in mind was to obtain a tremendous volume of business, which could be distributed over the 24 hr. as evenly as possible in order to sell electric light and power at a cheaper cost than would be possible under any other circumstances. As a result of his endeavors Chicago today has the lowest electrical rates of any large city in the world.

To make this "volume" business possible, Mr. Insull early became the pioneer in the power plant field for installing new devices, particularly the late costly machinery, high powered, economical and designed particularly for large scale production.

But it is characteristic of Mr. Insull to paint a complete picture. When his visions lead him into the highly technical or the mechanical end of his business he can no more help following the chain of reasoning clear through to the end than he can fail to make a success of anything he undertakes. Hence, when he saw in his dreams the giant production of today he also visualized the way to sell it, to make it a necessity and an economy for every home. Selling plans are his hobbies, and he is a devoted believer in advertising. He was quite human enough to foresee and eleborate upon the boon which cheap electric current would be to the housewife, and he made it possible for her to have it and to use it.

Mr. Insull believes that the great era of electricity still lies in the future, that its possibilities have just begun to be understood. He believes in regulated monopolies for public service corporations, on the ground

that greater efficiency, greater economy and better service may be rendered when one concern controls the situation.

In his dealings with the public he has made it a principle to be fair and frank. "Raising money is the hardest battle," he said once, "but I have found that the public is usually fair when it is acquainted with all of the facts."

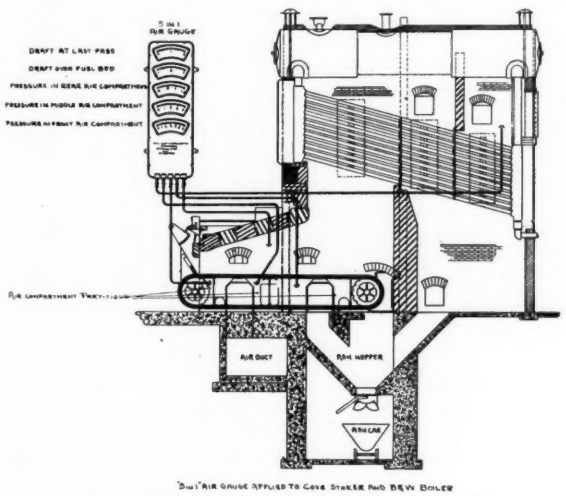
Every successful man has a recipe for his success, but Mr. Insull's is so broad that it seems at a glance to contain everything, as indeed it must. "For a successful career," he says, "it is necessary to have good health, imagination and persistence."

But on that farm up in Lake County, where 3500 acres spread out in fertile, well-tilled fields speak again for his efficiency, it is difficult to picture Mr. Insull as the man upon whose shoulders rests the responsibility for hundreds of millions of dollars.

"The greatest pleasure I find," said Mr. Insull, "is the pleasure of achievement—of doing things and building up—of creating something constructive."

Five-Pointer Draft Gage

INDICATIONS which enable the fireman to know the condition of the fuel bed are made possible with the draft gage shown in the accompanying illustration. Draft at the last pass, over the fuel bed, and at



APPLICATION OF GAGE TO STOKER AND BOILER

the first, second and third compartments is shown by the five indicating needles.

Variations in pressure or vacuum are transmitted by a diaphragm through an adjustable vertical plunger which is attached to a horizontal shaft by means of a link adjustable in length. At the side of the case are screw adjustments by which the operator may bring the needle to zero when necessary. Five main adjustments enable the movement to be accurately calibrated at every division. Opening to atmosphere, test cocks are provided at the bottom to test for accuracy.

Standard readings for the stoker drafts are from zero to 2 in. of water for the flue, 1 in. vacuum to 1 in. pressure for the combustion chamber, 0 to 6 in. for the front air compartment, 0 to 4 in. for the center air compartment and zero to 1½ in. for the rear air compartment.

Why Concrete Stacks Fail

FROM the day concrete made its advent in building construction, its merits were fully recognized. It must be admitted that for a large number of structures there is actually no better material than concrete. It became evident very soon, however, that it is an entirely unsuitable material for any purposes where it is subject to attack of heat, products of combustion, or undiluted acids. One of the best known structures in which such conditions prevail is the chimney.

For the moment, we do not want to discuss those where the structure collapsed during the construction or soon after. We refer for the present only to those which decayed rapidly soon after being put in use. The thin walls of the stack permitted rapid radiation of heat. Condensation took place on the inner side of the stack, and the condensate worked its way into the fissures, rapidly destroying the texture of the material, and attacking the reinforcing steel. The stacks started to lean, to burst open, or collapsed entirely. Recently this inherent defect has been in part overcome by using a lining of burned clay, extending the full height of the stack.

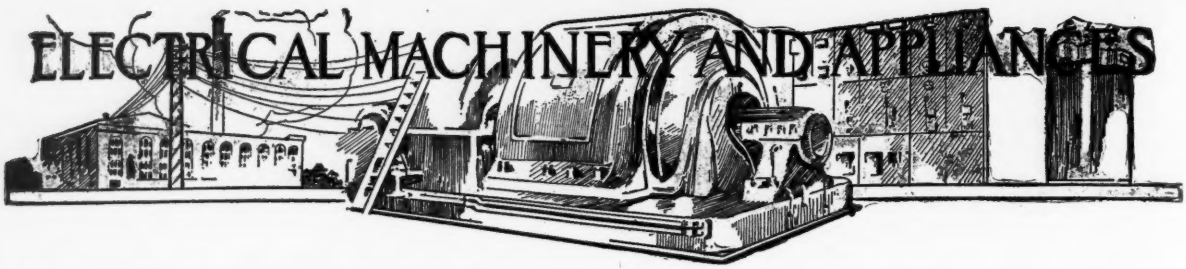
Graphite Pipe Joint Compound

THREADED JOINTS that are gas-tight, permanent and easy to open can be made by using graphite pipe joint compound. This is made in pastel form from selected flake graphite and a vehicle. As graphite is inert to all known re-agents, such as acids and alkalies, the metals are protected very thoroughly from all kinds of corrosion. To burn graphite requires a temperature of 1400 to 1500 deg. and pure oxygen, which makes the likelihood of burning out very small.

The compound is smeared on the threads and then screwed up into the fitting, thus giving a very uniform coating throughout. The ease with which the joints can be unscrewed makes it superior to either red lead or white lead, which depend for their effect on the hardening of the cement. For use around the retort doors where heavy asbestos gaskets are used, the compound gives the necessary lubrication so that the doors open easily without tearing the gaskets apart or injuring them. Here also it acts as a preventive of corrosive action and keeps the asbestos packing in fine condition for a much longer time than is otherwise the case.

The advantages this compound has over red or white lead and other cements are the tight joints possible, the ease of opening and the greater bulk. This compound for an equal weight has fully three times the volume, which means three times the number of fittings can be put together. Flanges, ground connections, cylinder heads—in fact, wherever metal surfaces come together tightly—can have pipe joint compound used to good advantage.

THE SUPPLY of first mates and first assistant engineers in the merchant marine is running short, and the Shipping Board has adopted a program to replenish it by promoting men in lower grades who are entitled by experience to take a step upward. Second mates and second assistant engineers, ambitious to advance in rating, are to be urged by officials of the Board's Recruiting Service to take an intensive course of study at free schools for officers maintained by the Board.



Turbine Generators of the U. S. Battleship New Mexico

By C. S. Raymond

INSTALLATION IN 1903 of a 5000-kw. turbine-generator marked a distinct epoch in steam-turbine units. Parallel with this is the application of the high-speed turbine-generator for propelling ships by electricity made possible by improvements in the art by which fuel consumption and weights per kilowatt have been greatly reduced. Experience gained from a large number of machines in operation has resulted in the elimination of untried constructions and materials in the turbine-generators for the U.S.S. New Mexico.

This ship is equipped with two main turbine-generator units, each generator designed to develop 10,500 kw. at 78 per cent power-factor, and 13,500 kv.a at full speed of the ship, and to carry a 25 per cent overload (16,850 kv.a. at 78 per cent power-factor) for 4 hr. The rotors have two poles and a maximum rotative speed of 2100 r.p.m., which corresponds to a frequency of 35 cycles. The stators are wound two-phase with leads brought out from the beginnings and endings of each phase to an eight-pole, double-throw, disconnecting switch placed in the main circuit between the generators and the motors. By manipulating this switch two generator connections, Fig. 1, are available: first, diametrical, two-circuit, low-voltage (3000 v.); and, second, square, one-circuit, high-voltage (4240 v.). With a constant flux, the voltage will vary directly or inversely as the $\sqrt{2}$, depending on the connection involved. Suitable interlocks have been installed, making it impossible to operate the two generators in parallel.

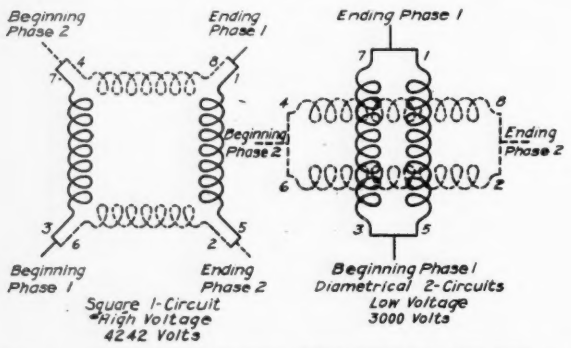


FIG. 1. THE SQUARE-CIRCUIT HIGH-VOLTAGE AND THE DIAMETRICAL-CIRCUIT LOW-VOLTAGE CONNECTIONS OF EACH TURBINE GENERATOR OBTAINED BY SWITCHING

All speeds of the ship up to 17 knots inclusive are obtained by the use of one generator having the low-voltage connection, the generator furnishing power for driving the four motors. Above 17 knots, two generators having the high-voltage connection are used, each generator furnishing power for driving two motors. The generator efficiency curve, taken at loads and speeds corresponding to 10, 15, 19 and 21 knots, is shown in Fig. 2. This curve shows a uniformly good efficiency throughout a wide range of load. It is based on actual running conditions and includes the windage loss of the rotor. The main turbine-generators are used only for propelling the ship, and are in no way connected to the lighting or other auxiliary power circuits. Therefore it is possible under the varying conditions of load to adjust the voltage and current to obtain good efficiency.

The induction motors, direct connected to the ship's propeller shafts, are two-speed machines with connections for 24 and 36 poles. Speed reduction between the generators and the motors when using the 24-pole motor connection is 12 to 1, and with the 36-pole connection, 18 to 1. Hence, the extreme range of generator speed for the specified operating speeds of the ship 10 to 21 knots is approximately 1440 r.p.m. to 2100 r.p.m.

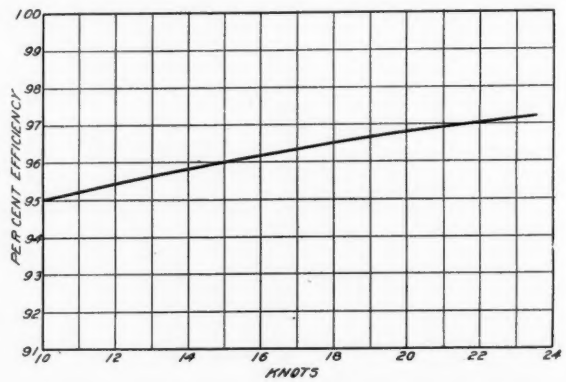


FIG. 2. GENERATOR EFFICIENCY CURVE TAKEN AT LOADS AND SPEEDS CORRESPONDING TO 10, 15, 19 AND 21 KNOTS

Generator Characteristics

Compared with maximum rated machines for land practice, the relative generator armature reaction is considerably lower and the densities in the magnetic section are slightly higher. The characteristics of these generators are best shown by the curves in Fig. 3, which are based on data taken from a four-hour maximum-load

endurance run. As indicated, sufficient excitation current is applied to the generator fields to insure keeping the motors and generators in step. In other words, the generators are not working at the peak of the kilowatt curve, but at a safe distance down where there is sufficient margin in power to take care of rudder swings and heavy seas. Based on the maximum power-factor of the motors, 79 per cent, the generators have a margin in power of 24 per cent with the excitation given.

Over Excitation

Another important feature in regard to the generator design is the condition of over excitation required for starting and reversing the motors. The turbine-generators have a fixed mechanical rotation, but the motors may be run in a clockwise or counter-clockwise direction by changing the phase rotation by suitable switching. A very important feature inherent with electrical propulsion is that full power is always available for either direction of propeller rotation. From actual reversal tests, at maximum speed of the ship, the observed excess excitation current required for reversal was approximately 60 per cent above that for the steady running condition. The line current increased to approximately three times the steady running value. That these high values of current are not injurious to the generator is due to the extremely short time required for reversal and the large heat storage capacity in the generator. The observed time for reversal from maximum speed ahead to full reversing speed astern, with the motors in the 36-pole or low-speed connection, was approximately 20 seconds. To pull the motors into step in the reversed direction of rotation required holding the over excitation on the generator fields approximately eight seconds, the balance of reversal time being consumed in the release of the interlocks and in the switching operation.

Mechanical Design

The mechanical design of the generator is similar to that of other machines developed for central power stations. Figure 4 shows a longitudinal cross-section of the two generators for the New Mexico.

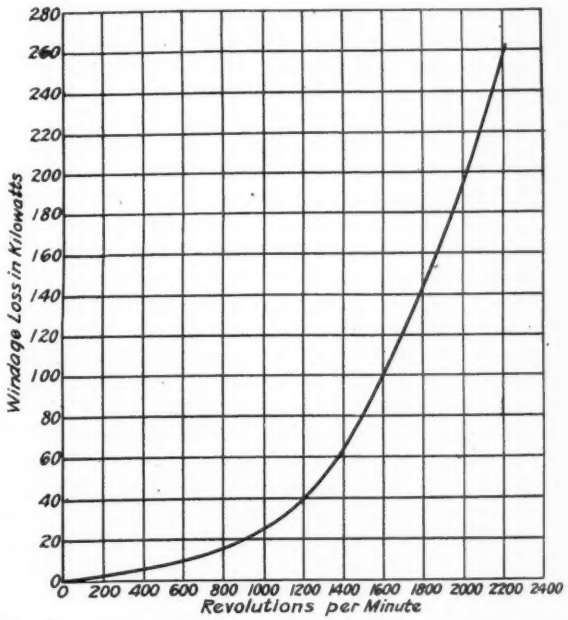


FIG. 3. CHARACTERISTICS OF NEW MEXICO GENERATORS

One feature that differs from land practice is the omission of the turbine and generator base castings. The turbine casing, generator stator frame and bearing standards are bolted directly to a stiff structural steel foundation securely tied in the ship's structure.

The stator frame is of the sectionalized I-beam type, which consists of several circular I-section castings,

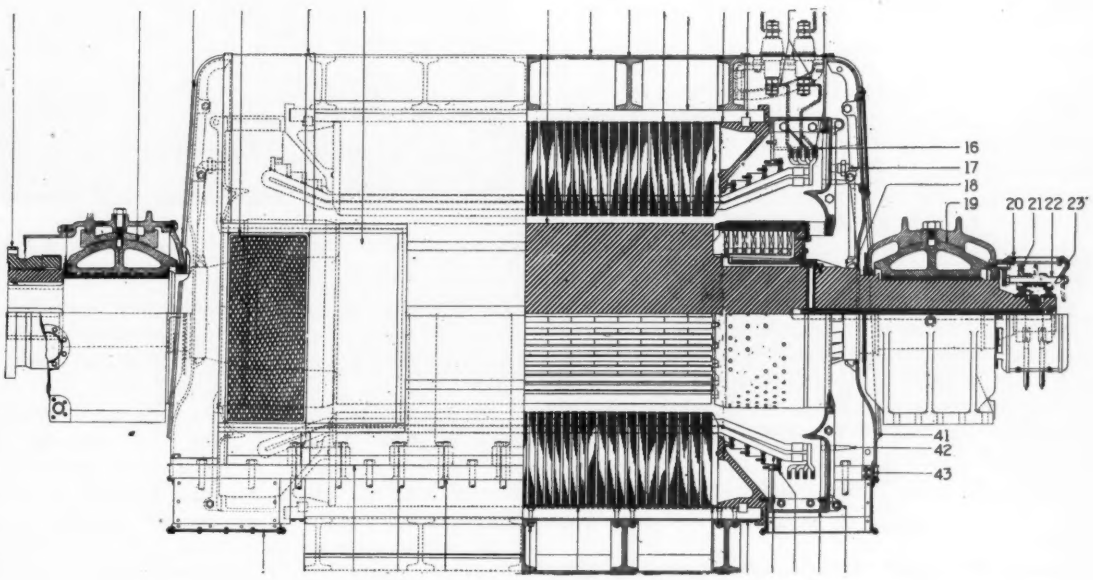


FIG. 4. LONGITUDINAL CROSS SECTION OF ONE OF THE TWO GENERATORS OF THE NEW MEXICO

properly spaced and held together at their outer periphery by boiler plates, these plates being hot riveted to the I-section castings. The I-section castings after being properly spaced and supported are carefully bored out at their inner periphery for the attachment of rectangular steel bars which form the dovetail ribs for assembling the stator core punchings. The punching segments and the dovetailing to the stator frame ribs are so designed that even with the great radial depths necessary for two-pole turbine-generators, the laminations lie flat. With the final pressure applied and the clamping flange assembled, a uniformly tight core is obtained.

Straight steel strips having an I-section were spot-welded to the punching segments and form the air ducts in the stator core. These strips or space blocks are so arranged that the air flows radially through the core. A liberal number of ducts are used to insure a plentiful supply of air and to expose the maximum amount of surface to the air.

The stator coils are of the conventional barrel type, two coils sides in each slot. The conductors consist of insulated rectangular wires which were formed into the proper shape in a bending form. Before the application of external insulation, the conductors were molded in a steam mold. Following this treatment they were placed in a tank and subjected to vacuum to remove the moisture, and then compound was forced into the coil under pressure to fill entirely the spaces between the rectangular wires. External insulation was afterward applied, consisting of mica tape which extends

FIG. 5. COMPLETED ROTOR FOR U. S. S. MARYLAND

uniformly over the whole coil. The molding and filling operations were again repeated. Recognizing the severe conditions that would be imposed on the insulation by the salt-laden ventilating air, water proofing insulation treatments were applied to the coils, special attention being directed to the connections and to the portions of the coils beyond the stator core. By heat treatment, the insulation of the coils is prevented from loosening under the most severe operating conditions.

To prevent distortion of the ends of the coils under short-circuit strains, they were securely laced to insulated binding bands. Blocks properly spaced were placed between the adjacent coils. The effectiveness of this structure has been demonstrated many times by actual short-circuit tests and additional short-circuits in such machines under commercial load.

Rotor or Field

The rotating elements of the turbine and the generator are supported by four bearings and are coupled together by a flexible jaw type coupling. This coupling is placed between the adjacent turbine and generator bearings and with them is contained within a common housing.

Radial slots for the rotor windings were machined in the solid forging. The rotor coils are made of rectangular copper strip wound on edge by a machine, which forms the corners of the coils and varies the span of each turn the correct amount. Before assembling the coils they were annealed and the turns insulated with mica type. The coils were assembled in the slots one turn at a time.

The slot insulation consists of mica and asbestos sheets placed between horn fiber for mechanical protection in assembling the turns. This insulation is a continuous sheet and extends the entire length of the slots. After assembling, the coils were heated by electric current, cemented and pressed into their proper position under a pressure exceeding that to which they are subjected in operation.

The portion of the coils outside the rotor body is insulated with mica tape. Over the mica tape is a layer of asbestos tape which serves as a mechanical support and protection to the mica. In the slots the insulation was lapped over the coils, cemented, the necessary filling strip inserted and steel wedges driven in to retain the coils in the slots. The end coils are carefully supported

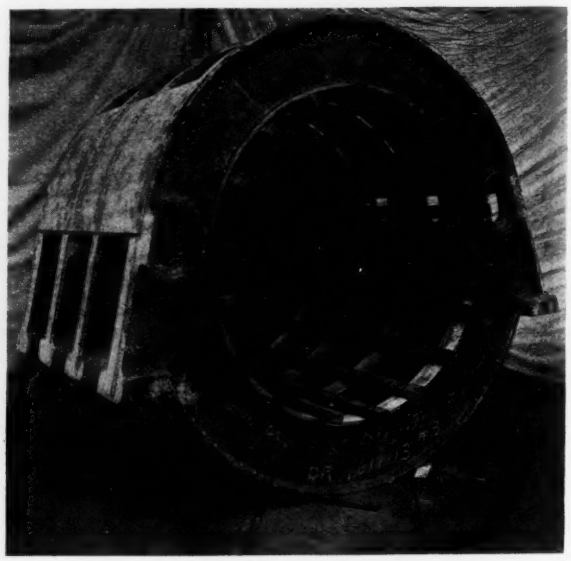


FIG. 6. SECTIONALIZED I-BEAM TYPE OF GENERATOR FRAME AS USED ON U.S.S. NEW MEXICO

by moisture-proof blocks to prevent any movement. To protect the ends of the coils from moisture several layers of insulating varnish was applied and each layer baked until dry.

To support the ends of the coils against centrifugal force, forged-nickel-steel binding-rings were shrunk on over them. One end of the ring is supported on lugs integral with the rotor body, the other end on a centering spider whose inner circumference rests on the shaft. Thus the shrinkage stress is taken by steel members and not by the insulation. A completed rotor for the Maryland is illustrated in Fig. 5.

Collector Rings

The collector rings are placed outside the collector-end bearing and are encased in a ventilated cover. This cover may be opened, similar to the hood on an automobile, to expose the brushes and brush hold-

ers for any necessary adjustment. The collector rings are special heat-treated steel forgings and were shrunk on over hard mica bushings to the cylindrical collector shell, this shell being pressed on and keyed to the end of the main shaft forging. Soft graphite brushes are used and spaced so that the entire width of collector ring has brush contact. A helical spring is placed directly over the center of the brush, and by adjusting this spring any desired brush pressure may be obtained.

Ventilation

The New Mexico turbine-generators are ventilated by two duplicate and separate ventilating systems, one for the starboard generator and the other for the port. The air is taken from out-of-doors through ducts placed just back of the upper superstructure on the starboard and port sides. The openings in these ducts face aft and are approximately 10 ft. above the main deck floor and are designed to prevent the entrance of rain. Auxiliary blowers of ample capacity draw in the air through these openings and force it down to the bottom of the ship into chambers directly under the generators. These chambers and the air connections to them are made water tight and the danger of bilge drainage entering with the air into the generator windings is practically eliminated. Fans mounted on each end of the generator rotor take the air from these chambers and force it axially through the air-gap. The air then passes radially through the several air ducts in the stator core, thence circulates around the outer periphery of the stator punchings in the spaces formed by the I-sections of the stator frame. An exit duct of liberal area is attached to the top of stator frame and the heated air is taken away through this duct which passes through the several decks and exhausts out-of-doors.

Generator Fires*

Means of Minimizing Occurrence and Limiting Extent of Damage; Fire-Fighting Equipment

CONSIDERABLE attention has lately and is now being given to the matter of fires originating within the generator shell of turbo-generators of the enclosed type with the object of (a) Determining means of minimizing the occurrence of such fires; (b) limiting the extent of the damage to as small a section of the generator as possible, and (c) providing fire-fighting equipment which can be applied quickly where it will be most effective.

The heavy loads carried by generators during the past two years and the inability to take the units off of the line for proper cleaning and inspection at the accustomed intervals, brought about by the heavy demands for power resulting from war conditions, have increased the number of generator failures and fires and thus emphasized their seriousness, not only in cost of repairs but even more in the enforced idleness of the entire unit during time of repairs. The desirability and necessity for more careful study of this entire question are therefore evident.

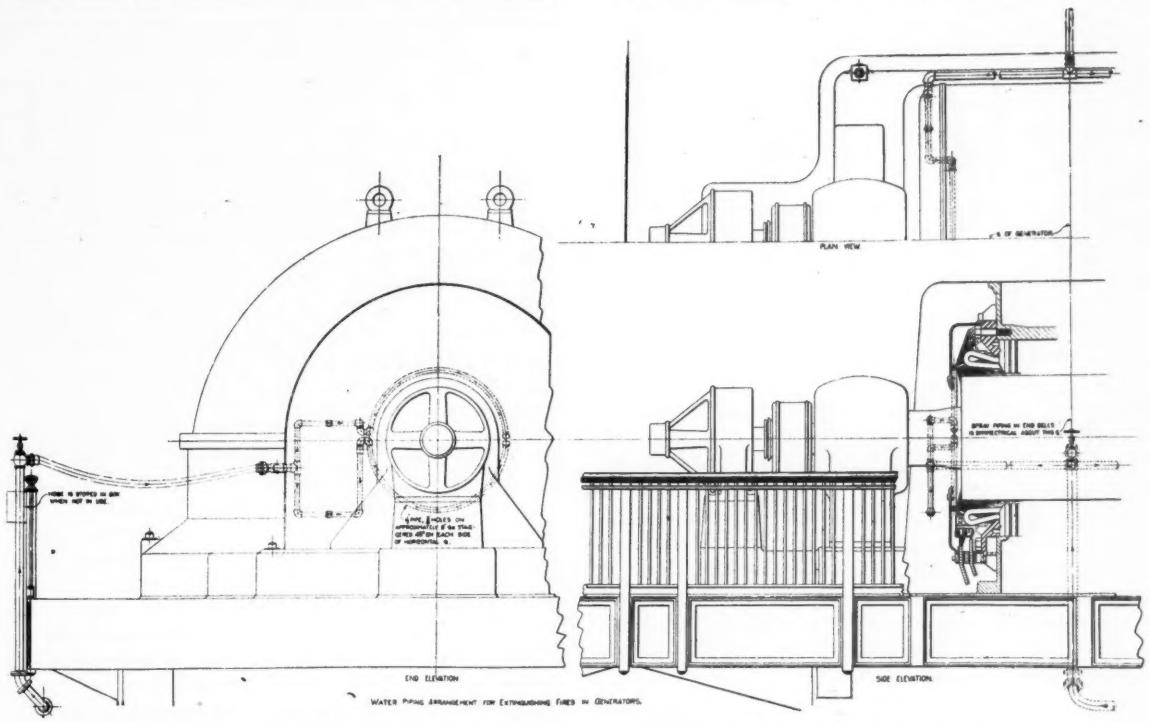


FIG. 1. WATER PIPING ARRANGEMENTS FOR EXTINGUISHING FIRES IN GENERATORS

* Abstract of report of Committee on Electrical Apparatus, read before the National Electric Light Association at the 42nd convention, May 19-22, 1919.

The origin of the fires reported seems to be fairly evenly divided between those external to the insulation surrounding the copper conductors and those internal from the conductors themselves. In many cases all evidence on this point is destroyed by the fire itself. The greater proportion of fires originating from sources external to the insulation seem to occur on 3-phase systems operating without a grounded neutral.

The various fires have been attributed to many causes —about one-third appear to be due to short circuits between conductors, and a greater number to grounds, while the remainder are divided among mechanical causes, eddy currents, corona and moisture from faulty operation or from freezing of air washing apparatus, condensation, etc.

Fire Prevention

Inspection and cleaning of turbo-generators at more frequent intervals would seem to be desirable and to have a direct bearing on the liability to fires from sources external to the winding. Every precaution should be taken to limit the amount of dirt and oil which may enter the generator, and many operating companies,

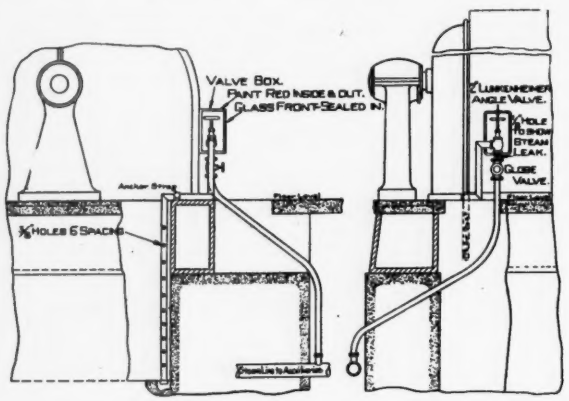


Fig. 2. Showing application of steam pipe in generator air inlet

particularly on the larger units, have standardized the installation of air washers. Even with the best possible condition of cooling air, however, it is evident that dirt will lodge within the generator, and if a certain amount of oil vapor is also carried into the machine, the coil surfaces and other parts may become coated with grease. Good practice, therefore, would seem to indicate that machines should be opened up periodically for thorough cleaning and possibly for painting. There seems to be a wide difference in practice with regard to the frequency at which such inspections and cleanings are made. It would pay to give attention to the matter of cleaning at least once a year.

Additional Insulation on Armature Coils

One member company feels that additional insulation on the armature coils of generators is as satisfactory a method of reducing the fire hazard as any that has so far been suggested. It is thought that this has a distinct advantage, and in some units it can be obtained for such a small increase in price that it may be the cheapest of all methods of reducing fire hazard. On two 35,000-kw. units for initial operation at 6600 v., arranged for future operation at 11,000 v., the manufacturer has guaranteed a high potential test on individual coils of 40,000 v. and on the complete machine of 34,000 v.

Grounded Neutral

Grounding of the neutral of 3-phase systems solidly or through resistance is rapidly becoming standard practice on both 25 and 60 cycles throughout the country. The consensus of opinion seems to be that grounding is very desirable and, in addition to other advantages, has a considerable effect on the reduction of generator fires occurring external to the insulation of the copper conductors.

It is also rapidly becoming standard practice, particularly on larger units, for the manufacturer to bring out both ends of each phase winding to the generator terminal boards, so as to permit the installation of current transformers between the terminals of the phase windings and the neutral of the coils. These current transformers can be connected differentially with respect to instrument current transformers in the leads between main oil switch and generator, so that in the event of a fault in the generator or its leads the balanced relay will immediately open the main oil switch, the neutral switch (if closed), and after a slight delay, the field switch. Many companies approve the installation of balanced relay protection and have adopted it as standard practice on all new generator installations and on older generators where the expense involved is not too great. The field switch is usually opened by means of an auxiliary switch on the main oil switch or by an auxiliary relay, so that there will be no chance of the field being opened before the armature has been disconnected from the system.

In the past there has been great reluctance to install any automatic features on generator equipment because of the fear of their erroneous operation. In 1912 a company installed balanced relay protection on tie line cables between two near-by generating stations, and their operation was so successful as to lead to a willingness for trial installation of balanced relays on a generator being installed in 1914. From that time on this equipment has proved very satisfactory and has been extended to all new machines on that system. It has now been rapidly adopted by other operating companies.

Reverse Power Protection

Before the introduction of balanced relay protection for generators, many companies installed reverse power relays, arranged, however, to operate signal lamps for indication to operator instead of tripping main oil switch. This was due to the fear of erroneous relay operation, which had actually occurred at times of system disturbances when generators were somewhat out of step. The reverse power relay thus does not limit automatic disconnection from the line to failure of the generator itself. The installation of reverse power relays is somewhat complicated in comparison with the very simple connections for balanced relay protection.

Fire Fighting

The modern type of turbo-generator is usually com-

pletely enclosed and subject to blower action for proper ventilation, so that fires in them become quite serious and difficult to extinguish. It should be particularly borne in mind, however, that the time element is the main factor in putting out any fire, and it is especially important in electrical generator fires to apply the extinguishing medium as promptly as possible and as close to the seat of trouble as can be done without danger of permanent injury.

In the methods thus far adopted for extinguishing electrical fires, water, steam and carbon-tetra-chloride have been used. Water and steam are looked on at present with favor. Large volumes of carbon-tetra-chloride would be required for any but small fires, thus involving great expense, with the added possibility of detrimental effect on the insulating materials and injury to operators from contact with the fumes. Moreover, it is quite difficult to apply this substance to the flame itself, and its use is therefore relatively ineffective.

Up to the time of the installation of permanent fire extinguishing apparatus for generators, water, because of its greater availability over steam, has been the principal medium for extinguishing, where Pyrene was ineffective. Experience has demonstrated, however, that it is extremely difficult to put out a fire in the generator before extensive damage has occurred without applying water directly at the seat of the trouble. In many cases reported it has been necessary to remove the end bells and direct the water stream on the windings.

With the advent, however, of permanently installed fire extinguishing provisions in generators, the use of steam has received serious consideration, and there is at the present time a wide difference in opinion as to the relative merits of water and steam for this purpose.

The principle of operating in using steam differs from that in using water primarily in that displacement of air in the generator by steam is largely depended upon to smother the fire. It is extremely important, however, in using steam to shut off the supply of air to the generator as completely and promptly as possible, and some means of facilitating this operation should be provided. It would seem that the air damper could be placed more effectively in the outlet rather than the inlet wherever the design permitted. The wetting of the generator windings from condensed steam may also be helpful. In using water, the idea is to wet the windings as far as possible, this being aided by the natural ventilation of the machine.

The possibilities of liquid carbon-dioxide or other non-combustible gases or liquids have also been discussed, but no advocates of these materials have been found.

Character of Apparatus

For the ready application of water to the generator windings, the usual practice is to provide pipe rings, which are fastened at each end of the generator inside of the end bells. Perforations are located in these pipes so as to throw a fine spray of water over the entire winding and over the air gap between the armature and field. The pipe rings are then connected together into a reliable source of water supply under the desired pressure. Figure 1 shows the general arrangement of this type of installation. The natural ventilation of the machine helps to spread the water over the entire winding.

For the ready application of steam to the generator windings two methods have been used:

1. Steam pipe arranged inside the end bells, perforated so that numerous jets will impinge directly on the end portion of the windings and into the air gap in practically the same way water is used.

2. Location of perforated steam pipe in the air inlet of the generator.

In both of these cases the steam supply is obtained from the branch system mains supplying the auxiliaries of the unit protected. The second plan has been adopted by some because of a fear that the steam may have a deteriorating effect on the insulation when it impinges directly on the end turns, as in the first plan. Figure 2 illustrates this type of installation. In applying steam it is the rule of one company that the valve be opened for 2-min. intervals, additional applications being given only if the fire continues.

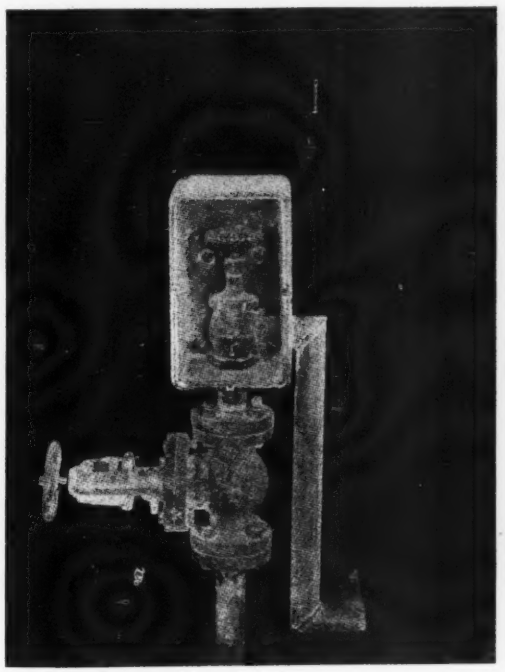


FIG. 3. SEALED VALVE USED ON STEAM SUPPLY LINE

Safety Precautions

It is, of course, very necessary that the possibility of the application of either water or steam to the generator winding, either accidentally, through leakage or malicious intent, be carefully guarded against. Various means have been devised to accomplish this purpose. The Duquesne Light, in connection with its provision for application of steam to the air inlet under the generator, has arranged the supply pipe to the generator with two valves in series joined by a short nipple, the valve nearer the machine being enclosed in a cast-iron box with glass front, which must be broken in case of fire before the valve can be operated. A small hole is drilled in the pipe nipple connecting the two valves,

which will positively indicate any leakage taking place through the first valve.

The Philadelphia Electric, which has provided for the use of water, has arranged that the water supply line is not permanently connected to the generator piping. The free ends of both pipes are provided with Jones or quickly attachable couplings, and a short piece of standard fire hose equipped with corresponding couplings is available for making this connection on the occurrence of a fire.

EVIDENCE OF FIRE AND APPLICATION OF EXTINGUISHER

WITH GENERATORS discharging air at the top into the turbine room, indication of fires within is promptly given to attendants by sparks, smoke or flame emerging from the unit. The tendency lately, however, in generator design, particularly in the larger units, has been towards bottom discharge into ducts leading to the boiler room to eliminate noise and to take advantage of the heat in the air. This design brings up a serious problem with regard to visibility of distress. Manufacturers

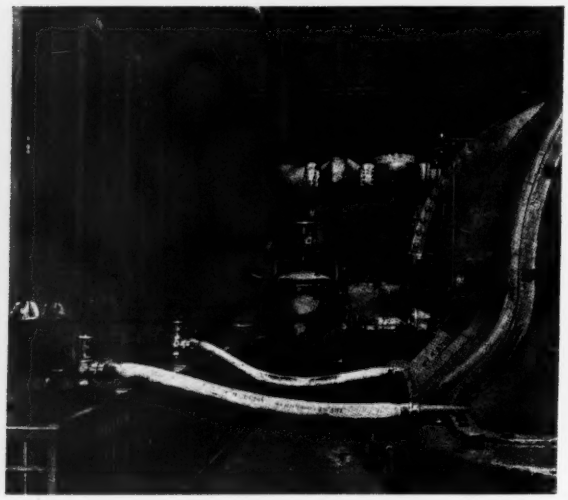


FIG. 4. FIRE CONNECTIONS EMPLOYED BY THE PHILADELPHIA ELECTRIC CO.

and operators would do well to give serious attention to this matter.

Some few fires have occurred from mechanical causes alone, such as fan rubbing against end bells, producing red-hot surfaces. These have led to an installation of glass windows in generator end bells for indication of such trouble. The advisability of using similar windows at the side of the base is worthy of consideration.

Before proceeding to fight any generator fire it is, of course, absolutely essential that the unit be disconnected from the line and the field opened. With the balanced relay protection, this is done automatically when fires involve a breakdown from the copper conductors on a grounded system. On other occasions the disconnection of the generator must be performed by hand as soon as it is evident that the unit is in trouble. The decision to apply an extinguishing medium and the time of doing so must now be left to the attendants. It is desirable to have a pilot light on the turbine gage board connected across a generator potential transformer to indicate when the unit is generating, and also perhaps a red lamp on the gage board to light upon the operation of the balanced relay. These indications would be of value in determining the time when an extinguishing medium could or should be applied. It is essential, however, that some visible indication be given of actual distress before applying of extinguishing medium.

It will be necessary after application of water to the generator windings to dry them out before placing in operation again. Experiences have demonstrated that electrical generators may be sprayed with water for some time with no serious damage resulting, if they are thoroughly dried out before being again placed in commission.

Some opposed to the use of steam have expressed fear regarding the possibility of detrimental effects of high temperature on the insulation, particularly where steam is applied for a long period of time or where it impinges directly on the windings. The destruction of the japanning on the core laminations by the high temperature is also feared. The Duquesne Light Co., however, has had several fires since installing perforated steam pipes in the air inlet of its machines and reports satisfactory results. Nearly all of these fires were started external to the windings and were extinguished with one two-minute application of steam. On all but two occasions the generator was restored to service without being dried out, having been out of service only from 3 to 4 hr., and in one other instance the drying out was done simply by rotating the machine for about 7 hr. without short circuiting the windings or exciting the field. One fire, starting from a ground, developed into a short circuit, but on only a few coils was the insulation burned sufficiently to necessitate replacing them. This machine was entirely rewound, however, as it had been through a previous fire and was not in the best of shape. It appears, however, that the equipment installed by this company has not, as yet, had an opportunity to demonstrate satisfactorily its ability to handle severe fires, and until more experience data with such fires are available no definite conclusions should be drawn.

In one instance steam used for fighting a fire destroyed the japanning of the laminations and therefore made necessary the entire dismantling of the generator armature. Yet the same company has shown its faith in steam for this purpose by installing this means of fire fighting in this company's installations.

THE VARIOUS companies which write workmen's compensation and employers' liability insurance have assured the Federal Board for Vocational Education that it is their opinion that the re-employment of the disabled men coming out of the army and navy will not affect the premium rates for workmen's compensation and liability insurance. Prospective employers, therefore, are assured that by taking disabled, re-educated men in their shops and works will not be the means of causing a rise in rates from the various casualty companies. These assurances have been received from practically every company in the United States writing employers' liability insurance.

MOST OF the really great men in America have warmed their bare feet frosty mornings on the spot where the cows have lain down.

Don'ts for Refrigerating Engineers

By Edward Wolff

DON'T neglect ammonia leaks. It does not take long for a dollar's worth of ammonia to leak out if there are a few small leaks in the system. Go over the system once a week and test the joints with a lighted sulphur stick. The machine and the high-pressure side of the system in particular need watching. Test the condenser water and brine with litmus paper or Nessler's solution.

Don't neglect to pump out thoroughly before opening up any part of the system for alterations or repairs; some men have a habit of letting whatever gas there is in the machine blow to the four winds. It is just as easy to pump it out, much nicer to work around, and it saves the ammonia.

Don't break open an ammonia joint or any part of the system until you are sure that the pressure is off and the ammonia is all out; don't be too quick to open it even then. Loosen the bolts a little and then open the joint gently. In case there should be pressure on it you can draw it up again before it gets too strong for one to stay around it. You will at least have a good chance to get away. Some men have lost their lives by neglecting to take this precaution.

Don't pull up too hard on a joint that is under pressure; you may break the flange, lose a part of the ammonia charge, or even lose your life. If a joint does not stop leaking after it is drawn up reasonably tight, pump the line out and renew the gasket.

Don't neglect to shut off the condenser water if the condenser is shut down for any length of time, especially if it is old and subject to leaks. Allowing the water to circulate over it cools it too quickly and may start a number of new leaks.

Don't neglect to clean the frost off direct expansion coils or brine coils. In the case of direct expansion coils, the best way to do this is to run a hot gas connection from the discharge of the machine to the liquid line and pump hot gas into the coils; this will clean them quickly and thoroughly. Clean coils mean lower temperatures, or the same temperature at a reduced speed of the machine and at a lower operating cost.

Don't neglect to inspect the valves and the false heads, if there are any. See that they seat well, that the springs are not broken and are of the proper tension and that there are no scored places on the seats and valves where the gas can blow through.

Don't get excited in case anyone gets a dose of liquid ammonia or ammonia-saturated oil; douse him with water; turn the fire hose on him if there is one at hand. Water is one of the greatest antidotes for ammonia known.

Don't connect a stop valve in an ammonia line so that the flow of the gas or liquid tends to close the valve. The writer remembers a number of cases where the valves came off the stems and caused no end of trouble. In one case the valve shut off the flow and blew the relief valve on the compressor, and considerable time was wasted in locating the cause; also it made it unusually disagreeable in the engine room even for some time after the machine was shut down, and for a time it appeared that we would not get near enough to shut off the steam nearer than the boiler room.

Don't neglect to keep the oil out of the expansion coils. If there are signs of oil in the system, open the coils as soon as they can be spared and blow them out, first with steam and then with air, and be sure they are thoroughly dry before closing them.

Don't open or shut a valve without first checking to make sure that it is the right valve. Never spin an important valve shut. Close it slowly, and if you are working on a line that is not working there should not be a sound when the valve is nearly closed. In case you are on the wrong line—the discharge line of one of the working compressors, for example—there will be a hissing sound as the valve nears closure just the same as in opening a high-pressure steam valve or a throttle. When you hear this, be careful. Sometimes when you are shutting off connections between two systems it may be all right; in other cases it may be all wrong.

Don't use more oil than necessary. If more is used, it gets through the packing into the cylinder, or goes out through the gas relief line into the suction pipe and the machine and out into the system, where it is nearly as bad as oil in a boiler.

Don't pump oil into the compressor cylinder. Usually enough oil leaks in through the stuffing box and the gas relief line, in addition to what circulates around the system, to keep the compressor well lubricated. The only exception may be some of the old-style vertical double-acting machines. On these it may be necessary to pump in a pint or so every 24 hr.; half of this may be sufficient in many cases, and with the smaller machines up to 100 T.

Don't neglect to blow down the oil traps regularly. If you are not using more than a quart of oil every 24 hr. blow the trap at least every two days, and if the oil consumption is a gallon a day they should be blown every day.

Don't run the compressor excessively hot or ice-cold; either one means loss of efficiency and capacity. The best results are to be had in the average plant by keeping the temperature of the discharge so hot that the hand can be held on it without burning.

Don't circulate water in the water jackets of the compressors if the water is not warmer on leaving the jacket than on entering. To do so wastes water and refrigerating capacity.

Don't be satisfied with any old suction pressure. Experiment with the expansion valves and see how high you can get the pressure without making the machine too cold; then do your best to keep it there as long as the cooler temperatures remain the same.

Don't run with an insufficient charge of ammonia. Keep enough in the system so that there is at least from 4 to 6 in. in the gage glass on the ammonia receiver when running at maximum capacity. If the liquid level gets too low some of the gas will pass over to the expansion coils with the liquid. Power has been used to compress this gas and water to cool it, and when it passes the expansion valve it will take some of the liquid you

have spent power and water to produce to cool it to the temperature of the suction gas. You are not only doing useless work in compressing and cooling the gas, but in doing so some of the useful work already done in liquefying some of the gas is absorbed in cooling the gas that thus escapes into the liquid line, from too low a liquid level.

Don't pump a vacuum on the system unnecessarily. It is likely to draw air into the system, and it will be necessary to purge it out again.

Don't run with a high head pressure unless it costs more for water to keep the pressure down than it costs for coal to operate the compressor at the high pressure.

Don't neglect to purge the air and foul gases out of the condenser regularly; this will help keep the head pressure down and reduce the coal or power consumption. Any time the head pressure begins to climb without apparent reason, or some of the coils get cold, it is an indication of air or foul gas in the condenser, and it should be purged.

Don't neglect to pump out the air before putting any part of the system back in service that has been opened for alteration and repairs. It will save the trouble of purging it out later from the condenser, thus saving some of the ammonia charge, because invariably some of the ammonia escapes while the purging is done.

Don't start an ammonia compressor without first noting that every valve in the discharge line from the compressor to the condenser is open. Relief valves sometimes fail to work, and it is a ten to one shot that if the relief valves operate they will not seat properly afterwards until the seats are ground in again. Besides, it is dangerous to people who may be working at points above the machine. If the relief valves fail to work, or if there are none, the head is liable to blow off.

Don't fail to turn the water on the condenser just before or immediately after starting the machine. If this is not done until the head pressure becomes high leaks are liable to develop in the condenser and discharge line, both from the excess temperature and high pressure, and some of the gaskets may blow out. If allowed to go too long the results will be as bad as if it is neglected to open the discharge valves.

Don't neglect to watch the head pressure while starting. If some of the valves in the discharge line between the condenser and the compressor are shut, the gage will give warning in time to let you shut the machine down before the pressure blows the relief valve. It will also give you warning, in case you forget to turn the water on the condenser.

Don't be in too much of a hurry to open the suction valve when starting, especially if the machine has been shut down for a long time, without pumping down the expansion coils and suction line. Open the valve slowly and keep your hand on the discharge pipe, if possible. If this suddenly gets cold and the discharge valves begin to work unusually quiet there is liquid coming back with the gas, and the suction valve must be choked off until the machine begins to warm up again, otherwise it may wreck the compressor and may result in serious consequences to yourself or your fellow employes. If there is a slamming or pounding in the cylinder similar to an engine getting a dose of water, shut the suction valve until it stops, as this is an indication of a dangerous condition.

Don't forget to close the suction valve when shutting down, even for a little while, and don't forget to close the liquid valve in the liquid line from the receiver to the expansion coils, or to close the expansion valve when shutting down a machine, if it is working alone. If these details are not attended to the liquid will accumulate in the expansion coils and the suction line and make trouble when starting up again or until it is pumped out.

Don't forget to watch the stuffing box when starting up. This usually has to be tightened up when the machine is shut down for any length of time, and it must be let out again gradually as the rod and packing warm up.

Don't try to run the packing after it gets burned or hard and loses its resiliency. It will wear the rod and waste ammonia. Packing is cheaper than new rods or ammonia.

Don't neglect to keep the gas relief line from the oil lantern to the suction line clear at all times. Very often this gets choked up with old packing and foreign matter in the oil and there is no outlet for the gas that escapes past the first section of the packing. If you have consistent trouble with the packing you will most likely find this is the trouble, if everything else is in good order.

Don't try to run the packing after it gets burned or hard and loses its resiliency. The result will be a waste of ammonia, more than to pay for a new set of packing, in a short time, and in a short time your rod will need turning. Packing is cheaper than new rods or ammonia.

Don't run the crossheads too loose on an ammonia compressor, and don't tighten the shoes any old way. Either will make trouble in the stuffing box. Put the compressor crank on the crank end center and adjust the shoes so that the piston rod is the same distance from the guides at both ends of the stroke. On the most generally adopted design for horizontal double-acting compressors the engine and compressor are placed parallel and in this case the pressure on the compressor crosshead is just the reverse of that on the engine. Also there is a tendency, if the crosshead is loose, for it to drop to the lower guide while the crank passes the centers, and this causes packing trouble. If the compressor and engine are placed in tandem the thrust on the compressor crosshead is the same as that on the engine and the guides should be adjusted accordingly.

Don't guess that the joints on a new job are perfectly tight; pump an air pressure on the line and then paint the joints with a solution of thick soapsuds. If there are any leaks present they will be indicated by bubbles forming.

Don't be in too much of a hurry when pumping an air pressure test with an old machine on a system that has been in service for a long time. If there is oil in the machine or discharge line it may cause an explosion by the compressor getting excessively hot and igniting the oil or oil fumes. Run the machine slowly and keep plenty of water on the water jacket, if it has one. If the machine or discharge line gets very hot shut the machine down until it cools.

Don't forget to keep a rapid circulation of water when pumping out a double-pipe condenser or one of the submerged type, or else be sure to drain it thor-

oughly dry; otherwise it will freeze and burst. This also applies to a brine cooler.

Don't run an ammonia plant without some kind of an ammonia helmet. When something blows out, some day, it will save its cost in ammonia and may save your own or others' lives.

Don't neglect to cover thoroughly the section of the suction line outside of the coolers and also all brine lines. Bare or poorly insulated lines simply mean a lot of work with nothing to show for it.

Don't use lead gaskets in discharge lines or high temperature parts of the condenser. Use some kind of asbestos sheet or some kind of rubber packing.

Don't use ordinary pipe for a liquid line unless you paint it with several coats of good paint to prevent rusting. Very often it has been found that the liquid line has nearly rusted through, even where it was covered. Every time the line is pumped down the line becomes frosted, and when this thaws off again the rusting action is aggravated. The best remedy is to use galvanized pipe; but in case the pipe is already in place, the second best choice is to use some kind of paint that will protect it against rust.

The Commercial Side of Engineering

By C. T. Baker

IT is essential that the engineer constantly bear in mind that his employer or client, as the case may be, is investing money in machinery and equipment for the sole purpose of making more money, and he therefore rightfully expects to earn a reasonable return on his investment. If he could not do this, there would be no incentive for him to encumber himself with the worries and hardships usually attending the launching of new enterprises or the maintaining of an established business which, in the nature of things, calls for a frequent outlay of cash, if a property is to be maintained in accordance with the accepted practice.

It is therefore apparent that the engineer who is charged with the selection of machinery and equipment for a given case, whether it be an entirely new power plant, the extension of existing plants or renewals, replacements, etc., has a responsibility of considerable magnitude, and in order properly to safeguard his employer's interest he must be a man of sound judgment, must know accurately the requirements of a given situation and must know what particular type of equipment or machinery will best fit a given case, and, all things considered, such as first cost, maintenance and depreciation, reliability of operations, etc., earn the biggest interest on the money invested. In this connection it should be borne in mind that false economy is just as dangerous as other species of poor engineering and management.

To cite a concrete example of false economy, a few years ago it became necessary in a certain small city to increase the pumping capacity of the local water works plant and with this end in view a modern high efficiency pumping unit of a capacity greatly in excess of the requirement, both as to present and future needs, was purchased and installed. The pumps were driven by compound Corliss steam cylinders and the unit as a whole represented the best in engineering practice. The builders' guarantee as to economy was very glittering and attractive and great performance of economy was expected. However, trial tests were very disappointing as regards economy and finally when the builders were called upon to make good, the city fathers were informed that the performance guaranteed was based on 150 lb. of steam at the throttle. It then developed that 110 lb. was the limit placed by the boiler insurance company. Also, the cast-iron fittings used on the steam supply piping throughout the plant were not suitable or safe for over 125 lb. working pressure.

As the present boilers were in good condition and would be useful for several years, it was felt that they should not be thrown out, and besides there was not sufficient money available with which to build a new boiler plant, consequently the proposition boiled down to 110 lb. steam pressure and a bad investment.

Good preliminary engineering and investigation would have shown that electric current at an attractive price, particularly at off peak periods, was available, and that an electric-driven installation consistent with the requirements could have been installed which would have represented a much lower first cost and investment and lower operating costs as well.

Had this type of installation been objected to, a steam-driven unit in keeping with the local conditions could have been installed which would have given good results, and, everything considered, much better over all economy.

A class of men who are in position to contribute to correct engineering and to influence and aid the commercial side of engineering in steam plants, ice making and electric plants, etc., are the operating and chief engineers of such plants.

These engineers should give careful consideration to the commercial aspects of their engineering and should take advantage and make reports on this phase of their work. The benefits derived from such investigation and study will be two-fold: first, the engineer making the investigation and report will be benefited in that he will have acquired a better and broader understanding of engineering, particularly that kind of engineering which earns dividends for the investor, and, second, his employers will be benefited to the extent that he will install equipment in keeping with his requirements, and that when such matters as first cost, interest and depreciation, reliability and operating economy are considered it will be found to be capable of accomplishing its object satisfactorily and cheaply, and will unquestionably be a success, both from an engineering and commercial standpoint.

It is particularly important for engineers in charge of the operation of ice making, cold storage and electric plants to keep in mind and familiarize themselves with the question of manufacturing or production costs.

This not only applies to the cost of material and the cost of doing work, but to all the elements that go to make up the cost of producing a ton of ice, a ton of refrigeration or a kilowatt of electric energy.

There has never been a period in the history of the country when economy has, and will, play such an important role in the general scheme of things, and it is

possible that the very existence of people on this planet may, in future generations, be secured only through economy of the most rigid character.

It is true, this may be looking very far into the future, but it is also true that the present-day engineers owe something to posterity as well as to present society, and to the engineer striving for economy through the application of good sound commercial engineering, as well as pure engineering laws and principles, there is a great opportunity to do useful work in the vineyard.

It is impossible to cover fully, in a paper such as this, the question of the Commercial Side of Engineering; however, it is possible to treat of a few of the major considerations and present a few facts worthy of the serious consideration of all engineers striving for economy in engineering.—REFTIGERATION.

The Air Receiver

PROPER CAPACITY; CONSTRUCTION DETAILS; CAUSES OF EXPLOSIONS; MOISTURE IN AIR. BY FRANK RICHARDS

AN air receiver connected with an air compressor would seem to be about as simple a thing from the engineer's viewpoint as can well be imagined, and yet there are many things which might be said, and some which should be said, and reiterated, concerning it, its function and relations as essential to be borne in mind in the interest of correct and profitable practice.

The first detail to be specified concerning an air receiver for any given service is as to its size or volumetric capacity, in which particular it is at once as different as possible from a steam boiler; for while there are rules and formulas innumerable to determine the capacity of the latter, there are no such rules for an air receiver, and in the nature of things none could be expected. If we were called on to suggest a rule for air receiver capacity we would say, have it as big as possible, and even then its size would not be of much help.

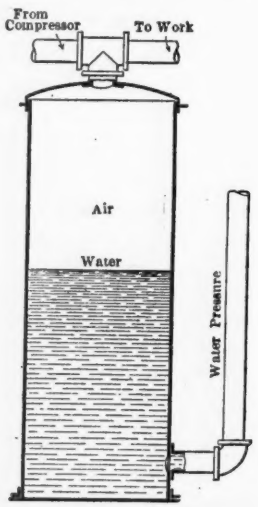


FIG. 1. AIR RECEIVER ARRANGED FOR CONSTANT PRESSURE

COMPARATIVE CAPACITIES OF RECEIVER AND COMPRESSOR

SAY THAT we had an ordinary single-stage air compressor with an air cylinder 24 in. in diameter running at 400 ft. per min. piston speed. Its free air capacity would roughly be about 1200 cu. ft. per min. and its delivery at 6 atmospheres or 75 lb. gage (after the air was cooled), 200 cu. ft. per min. An air receiver 5 ft. in diameter and 10 ft. long, which would be fully as large as would ordinarily be provided for such a compressor, would have a capacity of 196 cu. ft. only 164 cu. ft. of which, at 75 lb., would be in excess of the normal atmosphere content of the receiver, so that the total receiver capacity would be decidedly less than one minute's output of the machine. With the air not cooled, as would be the case, the deficiency would be still greater.

With a two-stage compressor of the same free air capacity and compressing to eight atmospheres, or, say, a little above 100 lb. gage, and the air at least partially cooled, the receiver capacity as above would more nearly approximate the one-minute output of the compressor. But the futility of installing the air receiver for storage purposes, besides its necessarily insufficient capacity, lies in the fact that the pressure of the contained air falls immediately with any withdrawal of the air, or, if in continuous operation, whenever the output exceeds the intake.

It happens that wherever compressed air is employed for operating rock drills, pneumatic tools, hoists or other devices, the call for the air is irregular and intermittent, and the problem of maintaining a constant pressure is difficult, and yet one of great importance. An obvious method, and perhaps the first to be thought of, would be to have the compressor capacity approximately equal to the maximum demand, and then to trust to the safety valve to dispose of the surplus when the air consumption fell off, but that, of course, would be crude and costly. Automatic speed regulation of the compressor usually does not give a sufficient range, and the fractional unloading of the air cylinder is more or less of a makeshift character.

CONSTANT PRESSURE IN THE RECEIVER

BY THE AID of static water pressure, which is usually available or can easily be provided, a constant pressure may be maintained in an air receiver whatever the fluctuation of its air content may be, of course within the limits of its capacity; and, wherever there is any permanency of installation the arrangement should be adopted. Figure 1 is practically self-explanatory as to the principle involved and the mode of its application. The bottom of the receiver, the vertical type being preferable but not essential, is connected by a pipe of suitable size with an elevated body of water, either a tank provided for the purpose of capacity greater than that of the receiver, or any existing body of water whose surface is at the required elevation. It will be seen that with the receiver partly filled with water and compressed air above it, the air pressure will be determined

and maintained by the height of the surface of the water in the tank above that of the water in the receiver. Thus for a pressure of 50 lb. gage in the receiver the elevation of the water in the tank should be 107 ft., and correspondingly for any other pressure. There is free communication between receiver and tank, and as the volume of air in the receiver decreases or increases the water in the receiver will rise and that in the tank will fall, or vice versa, to correspond, and no water is consumed or wasted. With the water thus freely flowing back and forth, a very slight difference of air pressure in the receiver will occur on account of the varying differences of height of the two bodies of water, and, singularly, the pressure will be the greatest in the receiver when it contains the greatest volume of air and when the water level there is the lowest. With compressors in operation and a constant flow of air passing through the pipes, the air which is being used need not enter the receiver at all, if only a free communication between the tank and the receiver is maintained to keep the constant pressure.

The original and most notable employment of this principle was by Bruno V. Nordberg, by whom the arrangement has since been patented, at the group of mines of the Anaconda Copper Co., Butte, Mont. Here a battery of air receivers connected with a large tank of water at the required height maintains a constant pressure of 90 lb. gage, so that the entire compressing system, with a free air capacity of 20,000 cu. ft. per min., might be stopped for half an hour and the full air pressure maintained against maximum consumption.

Air Receiver Construction

The normal air receiver of the present day is a cylindrical steel shell of a length two or three times the diameter, and often much longer than if used horizontally, with bumped heads riveted in. When the receiver is large enough to have a manhole both heads are usually inserted, with the convex faces of the heads outward, as they should be, but for the smaller receiver the generally accepted custom has been to have one head as it should be and the other head as it should not be, or with the concave face of the head outward, just for the convenience of the riveter in manufacturing, a thing for the mechanical world to be ashamed of. The later developments of welding processes remove the last excuse for receivers so constructed, and, indeed, we may hope to see rivets entirely discarded in air receiver construction.

Every air receiver before being put into service should be subjected to a hydrostatic test to a pressure considerably above that to which it will ever be subjected when in use, and in determining what shall be the test pressure limit it will be well to consider that working conditions are more strenuous than the quiescence of the shop. There is liable to be more or less shock or jar, and especially there are possibilities of a great range of temperature changes, and also in course of time the receiver will be weakened by rust, all of which particulars should be allowed for, with an additional factor of safety above that. Commercial considerations make it inadvisable for the present writer to attempt to fix the precise test pressure limit to be adopted in any case.

Explosions from Static Pressure

The subject of air receiver explosions is an interesting and important one; and first of all we need a discriminating definition of the word "explosion," for so-called explosions of air receivers occur under two entirely different sets of conditions, and with differences of result and consequences which are almost incomparable.

First, there is the letting go of the receiver and the sudden escape of the air when its pressure at the moment is greater than the material of the receiver can withstand, all other conditions being presumably normal. The air pressure from some cause may have become greater than ever before, or the receiver may have been insidiously weakened. With so small a margin of safety as has usually been deemed sufficient, it is little wonder that these static pressure explosions should occasionally occur. When such an explosion does take place the results to the surroundings are usually much less serious than when a pressure explosion of a steam boiler occurs, because there is nothing but the confined air to escape, while in the steam boiler there is not only the actual steam in the space above the water, but this is followed up by more steam instantly generated from the hot water, and also frequently this is backed by the rush of masses of the water itself.

Explosive Ignitions

The fixing of working pressure limits, the safety valves and other precautions which should be provided, guarantee only immunity from explosions of the preceding type, and are of little account when there occurs the firing of an explosive mixture of air and oily vapor within the receiver or its connections. Concerning explosions of this character there is much to be said, and investigations of causes must have to do with much more than with the receiver itself. We must begin, in fact, with the beginning of the air compression, and even outside the compressor where the man in charge doses the machine with the lubricating oil; for in the use of lubricant in the compressor lies either danger or safety, and much which has to do with the ultimate economy and safety of the entire compressed air system.

It is encouraging to be able to note that the troubles attributable to the lubricant used in air compressors have been greatly reduced, especially when the vast increase in the number of compressors and in the volume of air used is considered, and perhaps we may more readily comprehend why this is so by comparing what might be called the ancient and the modern styles of practice in air compression. These lie not farther apart than a single generation of men, with no distinct demarkation between them, so that there are still survivors of the primeval to discredit the present.

The Ancient Air Compressor

The typical compressor of the earlier type, which we here have in mind, supplying air mostly to rock drills in mine or tunnel, was a single stage machine compressing the air to, say, 90 lb. gage, without any cooling devices for the air, and little thought was given to the effects of the presence of the lubricant except for the actual lubrication, and, as a consequence, the oil was used "liberally." Now the oil which is fed into the

air cylinder has no discharge or escape except into the air itself, by which it is caught up and carried along. At the point of its leaving the cylinder, and immediately thereafter, the heat of the air is sufficient to decompose the oil and leave the carbon to accumulate as a black, sticky mess of combustible material lining the air passages and the interior of the receiver, while the more volatile constituents of the oil are carried along by the air to wherever it is finally discharged. As to the latter, there is an authentic court record that a man in an Alabama coal mine was fatally asphyxiated by the oil fumes in the exhaust of an air-driven steam pump and heavy damages were collected.

Under the system of high-pressure, single-stage compression which formerly prevailed it was undoubtedly necessary to use much more oil than in these days, when such high temperatures and undivided pressures are avoided, and with the extravagant use of lubricating oil above spoken of the carbon deposit accumulated rapidly in the air receivers, and it was a frequent occurrence to have the material take fire and burn with such sudden fierceness that the receiver became visibly red-hot. It may have been the products of combustion resulting from such a fire that asphyxiated the miner spoken of above.

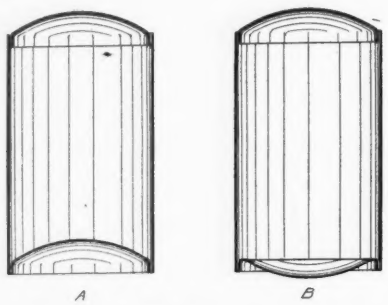


FIG. 2. FORM OF AIR RECEIVER BEFORE AND AFTER FIRE IN RECEIVER

It is not worth while to inquire how ignition could occur in such a case, as the heat of the compression and the presence of six times or more the quantity of oxygen per volume of air would alone be almost sufficient to account for it. The stopping of the compressor would, of course, stop or smother the fire at once for lack of fresh air.

Receiver explosions in connection with such fires did not generally occur. In one case there was a vertical receiver with the convexity of the head facing inward, as in Fig. 2A, and when the fire occurred the pressure of the air reversed the curve of the head and the receiver was lifted entirely clear of its support, as in Fig. 2B. Another receiver, horizontal, actually seen and photographed, after the event, by the writer, about 2 ft. in diameter and 5 ft. long, had a similar concave head which became red-hot, and while hot was reversed by the pressure, the reversal occurring with such a snap that the head was torn out entirely clear of the shell.

Two-Stage Compression

So much for the ancient and obsolete or obsolescent practice. The modern way is to have two-stage compression for the ordinary working pressures, say, from five to eight atmospheres, with efficient cooling of the air between the stages. By this arrangement the high temperatures are avoided, the oil has better lubricating effect, is retained longer upon the friction surfaces and less oil is required. More intelligent and careful supervision also is exercised as to the systematic feeding of the oil, and as an essential detail, careful records are kept.

It might appear in the light of the present, up-to-date practice that the function of the lubricant in the air cylinder is not altogether clear. The impression has been that more or less oil must always be present upon the friction surfaces. This belief is not easy to retain in the face of some indisputable records. On the Panama Canal work the tabulated records show 1,887,513 sq. ft. of cylinder surface swept by the piston per pint of oil used. This area is about 40 acres, and we cannot imagine a pint of oil could be made visible or otherwise discoverable if spread over such an expanse. A compressor of the Nevada Consolidated Copper Co. has more recently showed a rate of lubricating oil consumption only 1/3 of the above. At the present time there is more or less discussion current, which we will not here go into, as to the quality of oil most suitable for air compressors, our impression being that quantity rather than quality must be the determining characteristic. It is neither high flash-point nor a low flash-point, but, rather, no flash-point that will guarantee absolute safety.

Explosions in compressed air systems which result from the formation and then the ignition, or firing-off, of an explosive mixture which is composed of volatilized hydrocarbon from the oil intimately mixed with the air in receiver or piping, are very different from those which are caused by a slowly developed excess of pressure and safety valves, and other precautions against pressure alone, are of no avail when the instantaneous ignitions occur. The latter are also much the more dangerous and destructive, and therefore the more requiring investigation.

The lubricating oil which is fed into the compressor cylinder must be constantly in contact with the air passing through, and under the heat which develops in the compression some portion of the oil is converted from the liquid into the gaseous state, this portion mixing with the air and forming the explosive mixture under consideration. It may be reckoned a providential circumstance, otherwise taken advantage of in the gas engine, that the proportions of oily vapor and of air to form a mixture that will be explosive are quite narrowly limited. It may be said, generally, that if more than 5 or 6 per cent of the oil constituent is present in the mixture it will not be explosive; and it should be quite permissible for us to infer that many explosions which might be predicted do not take place on account of excess as well as of deficiency of oil vapor in the mixture.

But, supposing the potentially explosive constituents to be present in the required proportions and ready to go off, there is still the actual firing of the charge to be accounted for, and here, on account of the deficiency of actual knowledge, there is still more or less of mystery. We do not know with any precision the temperature required for ignition, and we cannot intelligently suggest how igniting spark or flame could be produced.

There are widely distributed data concerning the flash-points of oils, and also the so-called "burning" points, but beyond these there is also a temperature at which spontaneous ignition of an explosive mixture will result without spark or flame and started by the high temperature above. This is, indeed, the keynote of the Diesel engine, but the principle can hardly be said to have diffused itself through the familiar strata of popular engineering knowledge.

It is to be remembered that rise of temperature accompanies the compression of air, regardless of the means by which the air is compressed. In a certain coal mine in Pennsylvania a compressed air locomotive was employed for haulage. The mine was piped with air at a constant pressure of 1000 lb., and at different points in the mine there were stations at which the locomotive could make connections and have its tanks recharged to 600 lb. On one occasion of such recharging there was a fierce explosion with fatal results. There was a general disposition to dismiss the incident as an inexplicable mystery, and all the details of it were never fully investigated and explained.

There was in the case, however, sufficient suggestion of how the high temperature we were looking for might have been produced. We may assume that in this case oil was used with little thought to its possibilities, and that oily fumes were diffused through some portions of the air remaining in the locomotive, and that there was a small space somewhere in which the oily air was compressed at once by the inrush of the new air to the full recharging pressure, with corresponding rise of temperature, perhaps approaching 1000 deg. F., and then the conditions were complete for the spontaneous ignition and the resulting explosion, and the catastrophe was inevitable.

To account in another way for a self-igniting temperature, not necessarily resulting in an explosion, since the mixture might not be present, some ingenious person has invented the hypothesis of the leaky discharge valve as sufficiently explanatory, and the hypothesis is at different times commandeered by various writers. It is assumed that the heat of compression has produced from the oil a solidified carbon deposit which has accumulated and caked upon the discharge valves and cages, causing the valves to stick and fail to close properly. This we know well enough is not an infrequent occurrence, especially with single-stage machines compressing to six or more atmospheres, which was once the practice; but in connection with this sticking of the discharge valves it is further assumed that, notwithstanding that the compressor goes on taking in, compressing and delivering air, although perhaps in somewhat diminished quantity, a certain portion of the heated compressed air is caught and separated in some way from the rest and juggled back and forth at each stroke of the machine, and constantly being recompressed and getting hotter and hotter, apparently without limit, until it sets fire to what it may come in contact with. Now, ignoring the fact that such repeated recompressions and accessions of temperature, if they were possible, must necessitate also alternate re-expansions with accompanying depressions of temperature, such a hypothesis should be sufficient to account for almost anything.

Moisture in the Air

In dealing with compressed air in any way, the problem of disposing of the moisture contained in the air is practically encountered and imperatively demanding solution. Air taken in to be compressed, free air, is never so dry that it does not prove to be super-saturated after being compressed to five or six atmospheres and allowed to cool to normal temperature, and the air receiver has been popularly regarded as an important agent in disposing of the surplus moisture, but for that service it must be regarded as more or less a disappointment.

The Work of the Intercooler

To appreciate fully the possibilities and the impossibilities in connection with the air receiver and its attributed functions, it may be well to consider the practical operation of the intercooler of the two-stage compressor. Without the intercooler there would be no reason for and no advantage in two-stage compression. The primal argument for the intercooler is that it reduces the volume of the air under compression, leaving less work for the high pressure cylinder and thereby saving power. It may as well be conceded that this result alone would scarcely be sufficient to enforce the general adoption of the intercooler, its incidental services being really of more practical value than the mere saving of power.

The reduction of volume effected by the intercooler is merely a consequence of the reduction of temperatures, but the reduction of temperatures is in itself a great good accomplished. The deposition of the carbonized residuum of the oil upon the valves and in the air passages is greatly reduced and the spontaneous ignition of the oily deposits, or the firing of explosive mixtures which might be formed, is rendered practically impossible. The lubricating oil also remains in better condition and lasts longer upon the friction surfaces, so that less oil is required.

Condensing the Mixture

The cooling of the air in the intercooler, for the primal purpose of reducing its volume, also provides the conditions most necessary for the separation and extraction of the moisture carried by the air. Up to the point of complete saturation of the air, by water carried by it and which in greater or less quantity is always present, is in the form of steam, not steam under the conditions with which we are most familiar, with its boiling point at 212 deg., yet true steam. We must remember that under varying conditions water may have its boiling point, and its point of re-condensation, anywhere either above or below 212 deg. It is true steam that is carried by the air, and normally with all the accompanying phenomena of true steam, and the water can be eliminated from the air not by any process of straining or filtration, but, first, by the condensation of the steam and then by the deposition and collecting of the water of condensation. Any intercooler is thus a condenser, and might properly be so called, whatever its construction, so far as it accomplishes the purpose of converting into liquid the vapor that is mixed with the air.

Very roughly stated, the capacity of air for moisture at the saturation points and at any constant temperature is directly as the volume, or inversely as the absolute pressure. Thus with free air at 50 per cent of saturation, and it is generally above rather than below that, it will, at the same temperature, be completely saturated when its absolute pressure becomes two atmospheres, or, say, 15 lb. gage, and its volume is reduced to one-half.

At the same time it is to be remembered that the capacity of the air for moisture is much more rapidly affected by changes of temperature. As a general rule, this capacity is doubled with each rise of temperature of 20 deg. F. Thus, in the case just cited, when the air theoretically becomes completely saturated, so far as the pressure alone was concerned, when a pressure of two atmospheres was reached, the operation of raising the pressure of the air by 15 lb. at the same time raised its temperature more than 100 deg., so that by this rise of temperature the moisture carrying capacity of the air was increased $2 \times 2 \times 2 \times 2 \times 2$, more than 32 times.

It will thus appear that the air which comes to the intercooler after its compression in the low-pressure cylinder is, on account of its high temperature, in an extremely "dry" condition, although its actual water content has not been reduced in the least. It is so dry, in fact, that the proposition to relieve it of some of its contained moisture seems almost absurd. And yet, assuming the aftercooler to be properly designed and equipped for its purpose, the parting of the water from the air begins quite early in their transit through the apparatus, and continues with increasing rapidity until the cooling of the steam-and-water mixture is completed.

The typical intercooler might be any air receiver in which have been mounted a great number of thin metal tubes of small diameter, so connected that they are all constantly full of cold water in active circulation, the air which is to be cooled filling the body of the intercooler and surrounding the cooling tubes, provided that, by means of baffle plates or otherwise, this air also is constantly in motion along the surfaces of the tubes, or preferably across them with impinging action. It is further arranged that the final emergence of the air from the intercooler is at the end where the cold water enters, thus insuring that the air as it leaves the intercooler shall be at the lowest temperature possible, and little above that of the cold incoming water.

The Condensation of the Water Vapor

The cooling action which takes place in the intercooler, when considered in detail, is not at any instant operative upon the entire body of the air at the time contained within the intercooler, but upon successive films of the air which come immediately in contact with the surfaces of the cooling tubes, hence we may see how the condensation of the vapor, and the separation and the deposition of the water, may commence immediately that the air enters the intercooler. Steam contained in the free atmosphere will be condensed, and globules of water will form upon the outside of a pitcher of ice water carried into a room of normal temperature, without perceptibly lowering the mean temperature of the room. In this case a very small cooling surface is presented to a large body of air which contains more or less water vapor, but yet the air immediately in contact with the pitcher is effectually cooled, and some of the vapor in it is condensed. The case of the intercooler is the reverse of this. In it small portions at a time of moisture-laden air are caused to flow over large cooling surfaces, and the result in kind is the same, but the quantities of moisture released are much greater. As the moisture in the films of air which successively come in contact with the cold tubes is condensed and adheres to the tube surfaces, the globules at first minute begin to grow larger and then run together to form large drops, and these run down and collect at the lowest point, where means must be provided, automatic or otherwise, for removing the water.

Aftercooler as Necessary as the Intercooler

The task, or as we see in detail, the several tasks, assigned to the intercooler may be satisfactorily and completely performed, yet the work it does in the nature of things cannot be more than half the work of that kind requisite to be done. All that the intercooler does is still, to make the job complete, more necessary to be done after the final compression and before the sending out of the fully compressed air to do its work. An air compressing installation cannot in these days be said to satisfy fully the demand upon it when it merely puts out so much air compressed to the given pressure, without regard to the condition of the air as delivered.

The air, in the first place, should be cooled at once as it leaves the compressor to reduce its volume and minimize the friction loss in transmission, which is a small matter in itself, but the cooling of the air secures for it the combination of conditions, highest pressure and lowest temperature, when its moisture carrying capacity is at the minimum, and advantage should be taken of this for drawing off all the water so released, and if this is not done the subsequent inconvenience, delay and other money-losing details should be added to the power cost and the other costs of the compression.

Those most intelligently seeking economy in compressed air practice today recognize these things. In the most up-to-date installations will be found not only the receiver, which seems to be inevitable, but also the aftercooler and the moisture separator, each individually supplementing the compressor, and all proving themselves worth while in practice. These things carry no operative expense except for the supply of water, and that is not consumed, but it is still usable for any other purpose, so that a more profitable investment could not well be found.

The Three-in-One Air Receiver

A final suggestion seems obvious. While the air receiver must apparently continue to be the inseparable adjunct of the air compressor, it should not be permitted to be only that and nothing more, but should embody within itself the means for thoroughly cooling the air, and also for collecting all the released water and as much as possible of the oil and dirt which have been carried along, and so enable the compressor to deliver its air, as it should, in the best possible condition, both for transmission and for use.

Expenditures for machine tools to carry out Government contracts during the war are estimated at $250,000,000.

Some Pointers for the Boiler Room

WHEN your car of coal arrives at the plant, don't assume that the weight is always the same that is called for on the shipping bill; the proper thing to do is weigh it yourself, and by so doing you find out how much coal you are paying for that may not be delivered, and again your coal consumption per horsepower-hour may be quite a little lower than by taking shipping weight. The cheapest coal is the one which by a test generates the most steam per dollar—in other words, evaporates the most water per dollar's worth of coal burned under the operating condition of your plant; but one must keep an accurate record of the water evaporated to prove anything to the manager or to the coal dealer if the coal does not come up to the standard. The fireman should not leave coal scattered all over the floor after firing or filling stoker hopper. It shows the work of a careless fireman, while it takes only a minute to scrape or sweep coal back into the pile. Always remember that any boiler plant can be made to come up to all reasonable smoke laws, but not always without some changes in the furnace design.

The water column should be blown down when the fireman first comes on duty, whether it needs it or not, then there can be no dispute about the column showing the true water level, and again he should not forget to open the safety valve once every day and to try safety valves there can be a sash cord attached to each level of safety valves and hung so they can be reached from the boiler room floor.

Every boiler should have two ways of feeding, and these should be used alternately to be sure that they are in working order; and when the boiler is being blown down never leave the blowoff valves, as there has been some serious damage by so doing, as one is apt to forget. A boiler should never be emptied for cleaning while the setting is hot—that is, if it can be avoided—for if it should be left empty long without washing it right away the mud and scale bakes to the tubes and shell. After the boiler has been washed, filled and brought up to pressure, be sure that the pressures are the same or equal in the boiler and header before cutting in, and see to it that there is no water in the branch lines, as it might cause a water hammer and prove fatal to the man cutting the boiler into the line; neglect has cost many lives and much damage.

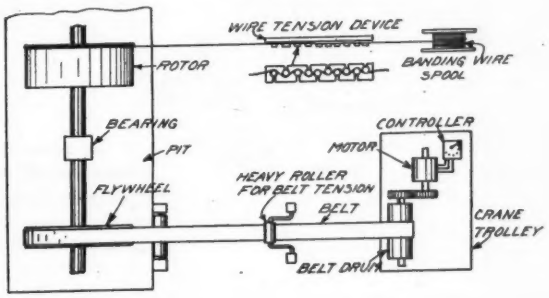
When the fireman is putting in gage glasses he should always have the drain valve open, and should close it very gradually, with the shutoff valves only partly open, and the face of the man should be turned away from the glass when putting the pressure on, for it may burst and throw glass in the face.

By calculating contents of pump cylinder, one can use it for approximate results of the amount of water fed to the boiler. The feed water should be heated with exhaust steam and fed to the boiler at or near 212 deg. F., but it is no economy to heat the feed, then pump through a long uncovered feed line. All piping should have a good covering to retain all heat possible. In taking the temperature of feed water, it should be taken right near the boiler; the feed water should not be discharged into the boiler close to riveted joints in shell or close to furnace sheets; the feed pipe should have open ends, and when a globe or angle valve is used on the feed line the inlet should be under the disc of the valve.

L. A. COLE.

Banding a Large Rotor

THE BANDING of armatures and rotors, when done in a factory where such things are an everyday occurrence, has been more or less reduced to a science, and the methods of procedure are many and varied.



ARRANGEMENT OF EQUIPMENT USED TO BAND 2000-HP. ROTOR

When the rotor to be banded reaches the 2000-hp. mark, however, it is out of the question to think of transporting it to the repair shop.

It occurred recently in a Middle Western steel mill that a 2000-hp. motor which drove the rolls, became seriously grounded. After replacing more than 40 coils which were hopelessly burned, the question of banding the rotor presented itself.

After some deliberation the following was decided upon. The entire trolley of a traveling crane was lowered to the floor and placed in line with a huge flywheel which was on the same shaft as the rotor. The cable drum of the trolley was converted into a belt drum by covering it with a canvas strip which was held in place by means of friction tape. This made a more or less flat surface and eliminated both the cable grooves and the grease from the face of the belt.

As the lower half of the flywheel was in a pit, it was necessary to place a roller at the edge of this pit as a

belt-runner. Another roller placed on a frame somewhat resembling a large brace, both ends of which were secured to the floor halfway between the crane trolley and the flywheel, was arranged so as to ride the belt and acted as a belt tension.

The banding wire tension device used in this case is similar in principle to those used on wire nail machines. The sheaves, being adjustable in the slots, may be tightened or slackened at a moment's notice.

MAURICE S. CLEMENT.

Condensate Return Traps

THE ACCOMPANYING sketches show an idea for a condensate return trap, live steam at full boiler pressure being used to force the water of condensation back to the boiler room or elsewhere as desired. It can be made from a piece of pipe 10-in., or larger, with an open and blank flange on each end, holes being drilled and threaded in the blank flanges and the sides of the pipe

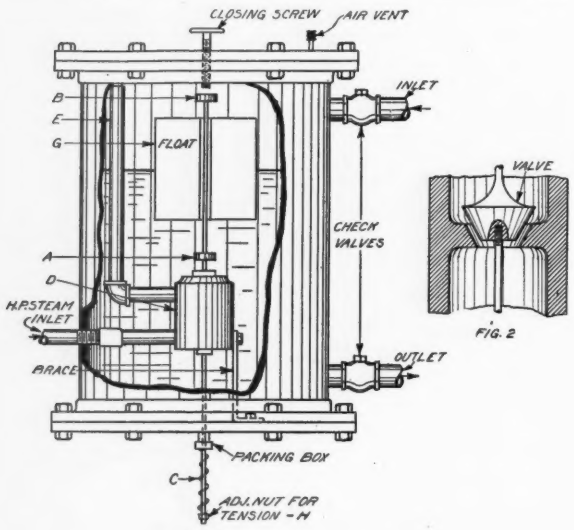


FIG. 1. IDEA FOR RETURN TRAP
FIG. 2. DETAIL OF STEAM VALVE

for the packing boxes, condensation inlet and outlet pipes and live steam pipe.

Inside the large pipe in Fig. 1 is an upright check valve, D, with a tapered disc (Fig. 2 shows the idea) to which is attached a rod; on this are check pieces, A, upon which the heavy copper float, G, presses downwards, and B upon which it exerts an upward pull.

The high pressure steam outlet is through pipe E. The weight of the valve, stem and pull of the spring at C holds the valve shut against the pressure of the steam; but when the valve raises by the float pressing against the piece B a larger area in the tapered valve is exposed to the steam pressure, than when the valve was shut. Also the pressure in the large chamber will not equal the pressure in the steam main for some seconds, so that the valve will remain open until the chamber is emptied of enough condensate to allow the float to lower upon the bottom stop, which, along with the pull on the spring, will close the valve. Figure 3 is a trap on the same principle, but of a different design, the live steam valve being outside. The air vent on either trap can be run in any way to suit the maker.

This trap is my own idea; it is not patented; I give the idea thinking some other engineer might improve on it and make something for himself on the side. Most return traps are mighty costly and I feel sure this one will work at least as well as some of those manufactured

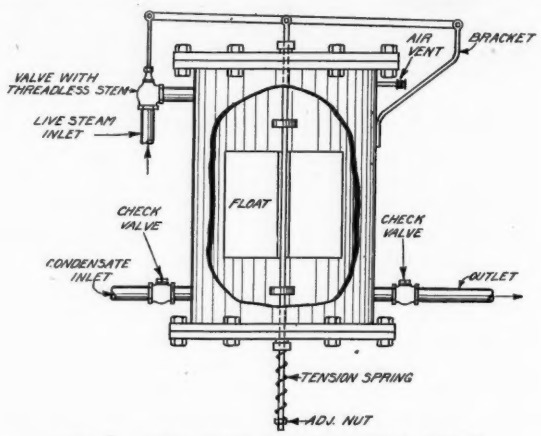


FIG. 3. TRAP WITH OUTSIDE STEAM VALVE

with which I have had experience. By the use of the outside tension spring good control can be had over the operation of the trap. JAMES E. NOBLE.

Loss of Vacuum

ONE DAY my engine, which was running smoothly, and with everything in order, lost vacuum without giving any warning or previous trouble, and became dead slow, giving out clouds of steam from the air pump, which was of open type, attached to the jet condenser.

As soon as it was noticed the engine stop-valve was closed, and we began to search for the trouble. It was thought that some obstruction in the tank might have blocked up the mouth of the injection pipe, and so the vacuum was lost, owing to absence of water in the condenser. Injection pipe and foot valve attached to it were examined and found to be in order. After filling up the air pump and cooling the condenser we tried to restart the engine, but the vacuum did not go up, and again the engine stopped.

Now it was a mystery to be solved. I could not think of any other cause, because everything was found to be in order. Giving my men orders to cool the condenser again and fill the air pump by the auxiliary cold water pipe, which was attached to an overhead tank, I was thinking about the matter, when an oiler came and reported that water was flowing from a hole in the auxiliary pipe.

As soon as I went and saw it I had the problem solved, because the air was passing through the hole direct to the condenser. The hole was about ½ in. in diameter; it was blocked by filling in with red lead putty and a thin sheet of brass was wrapped round the pipe with string.

The cause of a hole being formed in the pipe suddenly was, in my opinion, the pipe being very old (about 30 yr.) had corroded, and metal of that part might have crumbled down by a jerk or any other cause. Any-

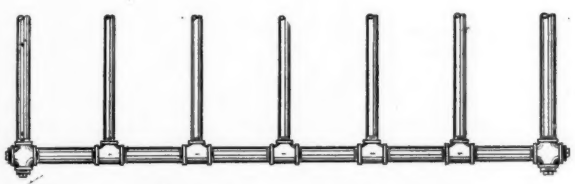
how, after repairing that hole the engine was started, and it worked nicely. So it proved that that hole was the *only cause* of the vacuum being lost.

I think the readers of Power Plant Engineering will agree with me that it was quite an unthinkable cause of the accident above referred to. No engineer, however competent, would have thought that a hole would be formed suddenly in an old pipe and give such trouble. It was only by accident that the defect was found out; if it were in a position unseen and out of the way it would have taken much time and caused a lot of trouble.

N. N. Bava Adam.

Arranging Feed Header for Convenient Cleaning

We endeavored to reduce the scale in our boilers by feeding chemical compound into our feed-water heater and while it materially cut down scale formation, it caused us considerable trouble because of the accumulation of mud and sediment in the main feed-water pipes, the scaling up of these being so serious that it was necessary to take them down every month or so and clean them out. After doing this several times, we cast about for some better method and finally hit on the scheme of putting in a feed header of a size larger than installed and then placing at each end of the loop a cross, as



BY REMOVING THE BLANK FLANGE FROM EITHER END CROSS THE HEADER MAY BE READILY CLEANED

shown in the accompanying sketch. These crosses have blank flanges on the two outboard ends and when the time came to clean the line, the flanges were simply removed and the mud and sediment scraped and pulled out by means of a long rod attached to an old boiler flue scraper which we adopted for the work. This simple rearrangement of the piping made it possible to clean the line out in a half hour's time and eliminated all the expense of tearing out the whole line at rather frequent intervals.

M. A. Saller.

Temporary Receptacle and Fixture

In a gas and electrical contracting house where the writer was employed, temporary work seemed to be the big point of the house. The following scheme was typical of some propositions that we had:

In one of our jobs, we had to make a form figure out of electric lights. In order to do so, we used porcelain receptacles to make this form. Due to a slip-up somewhere, we were short on receptacles, and as we had to have this running by night, which was not far off, it looked pretty bad for us. Therefore we got ⅜ by ⅜-in. male and female drop elbows which were left by somebody, and to these we screwed ⅜-in. brass sockets. We screwed these elbows to the figure by means of the flanges on them, and as our wiring was open, it was easy to tap onto these sockets. Although the hole was large enough to take No. 14 wire, we used fixture wire. While this meant a little more work, we had the pleasure of seeing it go into service only one-half hour behind time.

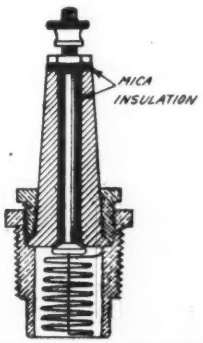
Since that time there have always been a few of these sockets and elbows made up, and they have been used many a time. We have since then used them as temporary fixtures on numerous occasions, especially on rush jobs where fixtures are held up. We always leave plenty of wire to tap to, and in our latter ones we used connectors which necessitated us to renew only beyond the connection.

Dean B. Cobb.

Oil Engine Ignition

The starting lamp for hot bulb oil engines as described by Old Hand in Oil Engine Operation Notes, May 1 issue, is very good; but the electric system of starting has the old blow-torch method beat for simplicity and speed in starting.

Electric ignition for oil engines as developed by Fairbanks Morse Co., for use on its "C O" oil engines (marine) cuts the time required for starting these engines nearly in half, besides being simple, positive in



CROSS SECTION OF PLUG FOR ELECTRIC IGNITION

operation, and from the point of safety alone, 100 per cent ahead of the torch method.

A coil of resistance wire of such size and length as to glow red hot with a current from a 12-v. storage battery, is set into a plug greatly resembling an ordinary spark plug and which screws into the bulb on the engine.

One terminal is grounded to the plug casing and the engine and the other end leads to the battery through a knife switch. On starting, the switch is closed, current passes through the coil and makes it red hot. After a minute or so, the engine is turned over (by air on large machines) and oil is injected into the hot bulb, striking the red hot coil, burns and forces the piston downward, continuing in operation automatically. After a few revolutions, sufficient heat has been generated inside the bulb to give it the temperature necessary to ignite the oil without the aid of the electric starter, which is then shut off.

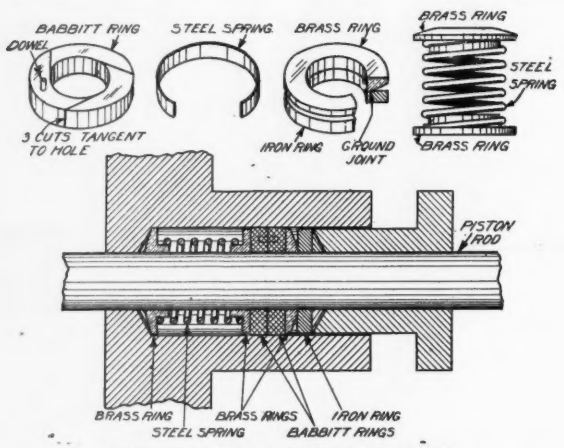
By a little judicious working of the oil pump by hand while the engine is warming up, full load can be put on in from 3 to 5 min. from time of starting; in fact, this type engine will do better work and warm up quicker if full load is applied almost immediately.

LeRoy R. Williamson.

Home-Made Metallic Packing Rings

I HAVE A high-speed engine, and I could not find any packing that would stay in the box around the piston rod. It is a vertical with an inclosed crank case and splash system of lubrication.

I decided to make some metallic packing for it. So I made a couple of babbit rings, cut them into three segments each and put in a dowel pin to keep the joints in one ring away from the joints in the other. I put a flat steel spring around each to hold them in place when there is no steam pressure on. On the outer end I made a ground joint with a brass and an iron ring. At the bottom of the stuffing box there is a spiral steel spring. At each end of the spring is a brass ring with



METALLIC PACKING FOR PISTON ROD

a flange to set down inside the spring to keep it away from the rod. The gland screws onto the outside of the stuffing box. While it is not absolutely steam tight, it has given satisfaction all winter, and I have since made a set for the valve stem. Cut the rings at a tangent to the rod so it can hug the rod close as it wears.

THE CHIEF.

Cutting Round Holes Through Glass

SMALL HOLES can be drilled through a plate of glass with a twist drill or with the broken end of a file; but where it is necessary to make holes of over, possibly, ¼ in. in diameter, it is difficult to form the holes by the drilling method. The method of grinding holes that is here described can be successfully used for a hole of almost any reasonable diameter. The method is particularly convenient for making the holes through the glass disks such as are used for the bushings of high tension entrances like that of Fig. 1. In this economical and effective type of entrance a piece of vitrified sewer pipe is built into the wall of the station. The pipe pitches downward so as to form a drip, and a disc of glass is cemented into the flanged end of the pipe. Through the center of this glass disc a hole is bored to provide for the admission of the high tension conductor. The disk is held in the pipe with neat Portland cement, and the hole around the conductor where it enters the glass can also be stopped up with the same material, provided the conductor is held rigidly and will not vibrate. Unless the conductor is held rigidly by insulators on each side of the entrance, its vibration will crack the cement.

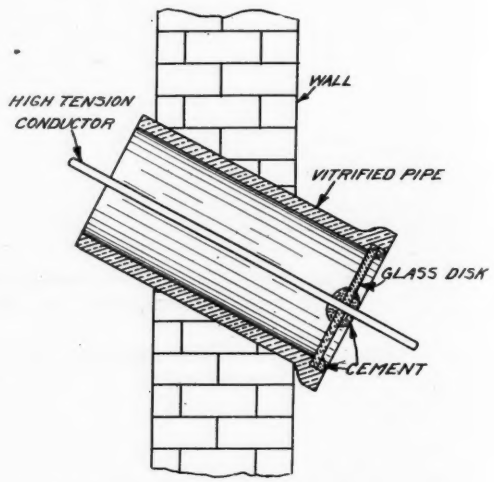


FIG. 1. GLASS DISK USED FOR WALL BUSHING

A hole can be formed in glass with the arrangement shown in Fig. 2. It is a grinding rather than drilling operation. A ⅜-in. diameter hole can be cut through a piece of glass ⅛ in. thick in about 8 min. with the method to be described, so it is obvious that the method is economical.

The grinding tool consists (Fig. 2) of a piece of copper tubing which should have an outside diameter equal to that of the hole that it is desired to cut. The wall of the tube should be at least 1/32 in. thick, but can be thicker. Where large holes are to be cut, the wall must be considerably thicker, so that the tube will be amply rigid. The tube should be straight and true. Its upper end is clamped in a drill chuck, and it should be driven at approximately the speed that would be used for a twist drill of the same diameter in drilling cast iron.

The glass plate in which the hole is to be made is carefully bedded and leveled on the drill table, and is firmly clamped with wooden blocks so that it cannot

move. Now the copper tube that is revolving, due to the operation of the twist drill mechanism, is lowered against the glass, and an emulsion of fine emery and machine oil is fed under the edges of the tool where it is rotating against the glass. The tube is raised, more emery and oil is pushed under its edges, and it is lowered upon. This process is repeated until the plate glass is drilled halfway through. The emery imbeds in the edge of the copper tube and thereby forms a quick-cutting, circular boring tool.

After the hole has been cut halfway through the glass on one side, the tube is raised and the glass is reversed. The hole is then completed from the reverse side. This prevents the glass from chipping around the hole.

Copper appears to be the best metal obtainable for these tubular glass-boring tools. Besides being so soft that the emery readily imbeds in it, it is a splendid

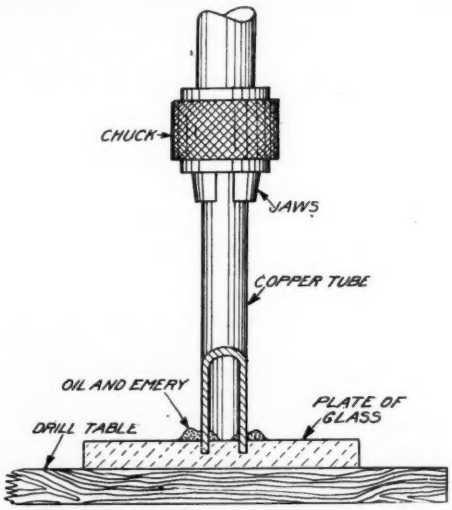


FIG. 2. CUTTING HOLE IN GLASS WITH COPPER TUBE

conductor of heat, and seems to carry the heat developed by the boring rapidly away from the glass and thereby prevents cracking. H. B. MANSON.

Crankpins

A CRANKPIN an a small Corliss engine broke off even with the face of the crank, and was replaced with another pin. After running about a year the new one broke at practically the same place as the first one. This time, when the new pin was pressed in, the pin was made with a fillet, or round corner, at A, Fig. 1. The edge of hole in the crank was rounded to accommodate the pin.

In another instance a Corliss engine developed a loose crankpin, and a local garage man undertook to fix it. He removed the connecting rod and drilled a number of holes for round keys at an angle, from the rod side, into the crank, so that half of the hole was in the crank and the other half in the crankpin, as in Fig. 2. This proved to be but a temporary relief, and the pin was soon loose as ever. So it was decided to put in a new pin and have a machinist from the factory where the engine was built do the work. He removed the old pin and bored out the crankpin hole, as at C, Fig. 3. A light cut was run full length of the hole to true it up, as the loose pin had worn it out of round. The new crankpin, Fig. 4, was turned, with the large part B to fit the large bore C. The pin was made long enough for riveting generously at the other end.

A crankpin, Fig. 5, about 6 in. diameter, drilled for a 1½-in. cap screw D to hold on the washer had an oil hole E about ¼ in. diameter and broke at F in line with the oil hole. The engine was running at full speed, when half the pin fell on the floor. The stub end of the pin projecting about 3 in. from the face of

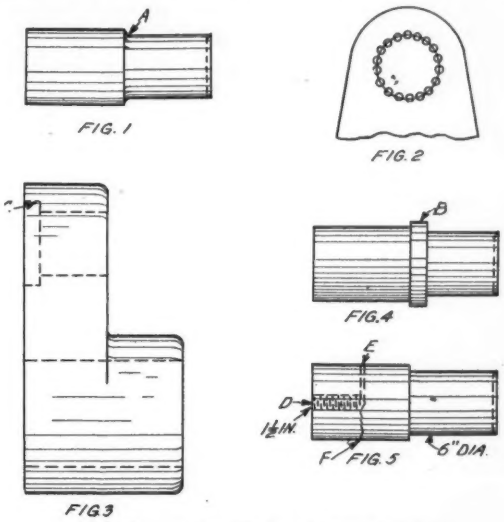
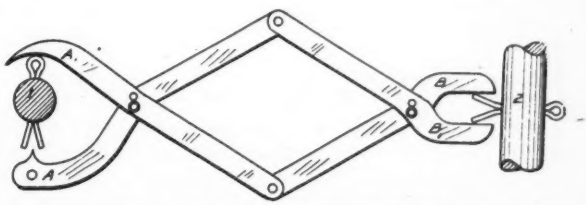


FIG. 1. CRANKPIN MADE WITH FILLET
FIG. 2. METHOD OF TIGHTENING PIN TEMPORARILY
FIG. 3. COUNTER BORED HOLE FOR CRANKPIN
FIG. 4. CRANKPIN WITH COLLAR
FIG. 5. SECTION OF CRANKPIN WHICH BROKE IN MIDDLE

the crank supported the rod, and the engine remained in operation without further accident until the throttle could be closed. This is what might be termed a lucky accident, as, had the rod dropped, the engine might have been wrecked. TOM JONES.

A Handy Cotter Key Extractor

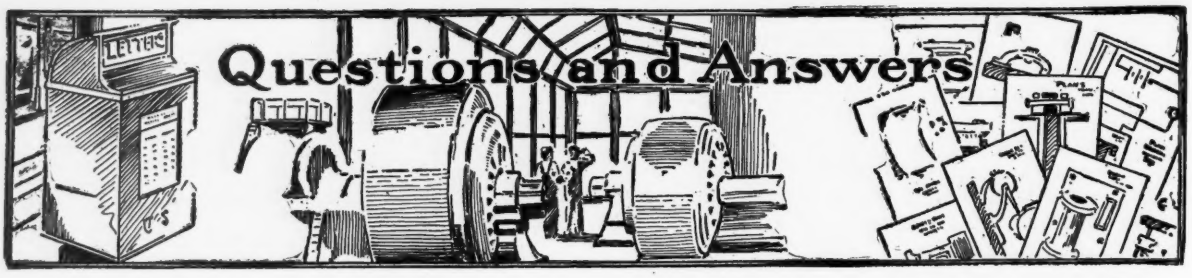
A HANDY COTTER key tool which eliminates the use of spreading chisels, hammers, pliers, etc., is shown here-



APPLICATION OF THE LITTLE COTTER KEY EXTRACTOR

with. As may be seen, this device may be employed not only for the insertion of cotters and the spreading of their legs, but also for the closing of the legs preparatory to extraction. OTTO DORTHEN.

ACCORDING TO the reports of French engineers who have investigated the mines flooded by the invading Huns, 30,000 hp. of pumping equipment will be required for two years to free the mines of water.



Setting Locomotive Valves

CAN one of the readers of Power Plant Engineering inform me as to the proper way to set the valves of a Vulcan locomotive? I would greatly appreciate receiving this information. J. S.

What Causes This Voltage Drop

I HAVE in my charge four alternating-current generators, the smallest one of which, a machine belt driven by a 300-hp. water wheel, is giving me considerable trouble due to low voltage. The unit is of the 3-phase, 60-cycle type, rated at 220 v. and 380 amp. When operating at a speed of 900 r.p.m., however, we carry but 300 amp. on it, and that from 7 a. m. to 5 p. m.

The trouble occurs directly after the noon hour, when the voltage will fall to 200 v. and remains so until 3 o'clock, when it will pick up and everything will again be all right.

At no time does the speed variation exceed two revolutions, and the exciter is also up to speed, which is 1200 r.p.m. I have turned down the collector rings and the commutator; the brushes are in good condition and do not spark. The frequency meter reads 60, as it should.

The only thing I do not like is the heating up of the machine around 11 o'clock in the morning, although the heating is not of such intensity as to make it uncomfortable for one's hand.

We have a Tirrill regulator which appears to be working perfectly.

I have tested out the machine for grounds, loose connections, etc.

Will not some of the readers of Power Plant Engineering kindly express their opinion of the matter and let me know what the cause of the trouble may be and how I may remedy it? G. I.

Merchant Marine Examination Questions

THE FOLLOWING list of questions may prove not only interesting but of value to those readers of Power Plant Engineering contemplating entering the U. S. Merchant Marine. The questions are typical of those asked applicants for engineer positions and were taken from lists of questions constituting recent examinations of the U. S. Shipping Board School for Marine Engineers at the University of California.

1. Show by sketch two different ways of making a seat for Scotch marine boilers. How are these boilers secured in place?

2. A boiler of the above-mentioned type has four grates each 6 ft. long and 40 in. wide and burns 20 lb. of coal per square foot of surface. Steam is maintained at 185 lb. gage and 9.75 lb. of water are evaporated per pound of coal burned. How many safety valves, according to U. S. rules, would be required?

3. A safety valve has a lever 44 in. long and weighs 10 lb.; the valve proper is 3 in. in diameter and weighs 8 lb. If the distance from center of valve stem to fulcrum is 5 in. where must a 110 lb. weight be placed if the valve is to blow off at 120 lb.?

4. What is a fusible plug? How, and of what material is it made? Where should it be placed in a Scotch marine boiler?

How should it be inserted?

5. What causes foaming and priming in boilers? How prevented?

6. How many 2½-in. steel stays will be required to stay an area of 3700 sq. in., assuming the boiler pressure to be 200 lb. gage and stress of 9000 lb. per square inch allowed on the stays?

7. Describe the following stays and tell where and how fastened: (a) Through stays; (b) gusset; (c) palm; (d) hanging; (e) screwed; (f) crowfoot; (g) tube.

8. How would you construct a salinometer? Explain in detail.

9. With oil-burning boilers using mechanical atomization, why is it necessary to heat the oil before burning it?

To what temperature is it ordinarily heated?

What pressure is used to force the oil through the burners?

Assuming the boilers dead, state three ways in which steam could be raised.

10. In the case of a Scotch marine boiler working under natural draft, how many pounds of coal would you expect to burn per hour for each square foot of grate surface?

Under favorable conditions how many pounds of water should be evaporated per pound of coal burned?

About how many square feet of heating surface are allowed for each indicated horsepower of the engine?

11. Each of the three furnaces of three Scotch marine boilers is 42 in. in diameter and 96 in. long. If you burn 25 lb. of coal per hour and evaporate 9 lb. of water per pound of coal burned, how many revolutions per minute will a 10 by 6 by 10-in. duplex double-acting pump have to make to feed these boilers? Allow 8 per cent pump slip.

12. A ship has two bunkers each 40 ft. long. The width of each of these at the top is 12 ft., at the bottom 3 ft. and at a point 4 ft. above the bottom they are 5 ft. wide; the total depth is 28 ft.

Give the capacity of these bunkers in tons allowing 45 cu. ft. to the ton.

13. If you had a combustion chamber made up of 9/16-in. plate and you wanted to carry 200 lb. pressure per square inch how far apart would you space the stays and what size would you make them? (Use constants of 120 and 6000.)

14. A lever safety valve is wanted to carry 150 lb. pressure per square inch, the valve opening to be 4 in. in diameter, the fulcrum distance 5 in. and the lever 36 in. long made up of a bar of 1 by 3-in. steel weighing 10 lb. per foot. If the valve weighs 12 lb., what size ball is required?

15. Which way does the main stop valve of a boiler open, with or against the pressure? What is the standard taper for pipe taps and dies? How is boiler tubing measured? How is pipe measured?

16. A 5000-gal. tank is to be emptied by a 12 by 10 by 12-in. double-acting pump fitted with 1½-in. rods and operating at a speed of 20 r.p.m. per side. Allowing for a slip of 5 per cent how long will it take the pump to empty the tank?

17. A 10 by 10 by 12-in. duplex double-acting pump has a 5 per cent slip. How many revolutions per minute will it have to make to discharge 200 tons of salt water per hour? Allow 35 cu. ft. to the ton.

18. Determine the indicated horsepower of an engine having a piston 40 in. in diameter and at 42-in. stroke and operating under a mean effective pressure of 80 lb. per sq. in. at a speed of 100 r.p.m.

19. Show by sketch the position of eccentrics relative to the crankpin for Stevenson link motion with independent cutoff using slide valves.

20. Describe a thrust bearing in detail. What is it used for and where is it generally placed?

In designing a thrust bearing what pressure per square inch is usually allowed?

21. With reciprocating engines what is the most economical vacuum to carry?

What is the most economical feed water temperature to carry? Of the hot well? Give reasons.

Give two ways of regulating the vacuum while under way.

22. Describe fully the means of communication between the bridge and the engine room.

23. Make a sketch of a double-ported valve.

24. What is vacuum and of what advantage is it to a marine engine?

Under like degrees of steam consumption about how much more power may be obtained by the employment of vacuum?

25. Define steam lap, exhaust lap, lead, angle of advance, angularity of rod.

26. Explain method of lining up an engine.

27. Explain difference between single and double-acting pumps.

Explain why neither will draw water that is too hot.

28. According to the engine room counter a steamship made 210.1 nautical miles in 23 hr. 50 min., the engine turned over 52.6 r.p.m. Find pitch of the screw.

In the same time by observation the ship made 173.5 mi. What was the average speed in knots? What was the per cent apparent slip?

29. How do you find the dead center of an engine? Describe fully.

30. Describe the Edwards air pump.

31. What would be the steaming radius of a ship making 15 knots, burning 30 tons of coal a day and having bunkers 50 ft. wide at the top, 30 ft. wide at the bottom, 30 ft. deep and 60 ft. long. Allow 40 cu. ft. of coal per ton.

Suppose this ship is to increase her speed to 20 knots and the coal consumption increases as the cube of the speed. What would be the steaming radius?

32. A propeller is 8 ft. in diameter and has 3 ft. blades with the forward corner of one 2 ft. in advance of the one following. Find the pitch.

33. What is the object of using a double-ported valve?

Name the advantages and disadvantages of a piston valve. Of a slide valve.

34. Why should vertical engines have more lead at the bottom than at the top end of the cylinder?

By inspection, how would you determine the direction in which an engine will run?

35. How many pounds of steam can you get from 1 lb. of water?

What is a fair average of steam consumption in pounds per indicated horsepower hour of a triple-expansion marine engine?

36. An engine has a 20-in. cylinder and a stroke of 36 in., the initial steam pressure is 120 lb. gage and the point of cutoff is at ½ stroke. The mean effective pressure is at 90 lb. and the speed is 110 r.p.m. Find the indicated horsepower.

37. Name the steam-driven auxiliaries required aboard a standard freighter burning oil as fuel.

J. C. STEWART.

Selecting Proper Lubricating Oils

SOMETIME ago I had a professional chemist make an analysis of two different kinds of cylinder oil; his reports read as folows: No. 1 oil shows a viscosity of 3.9 by 212 F., No. 4 shows 2.6 by 212 F.; he calls my attention to the rather low viscosity of No. 1 and of No. 4 he states it is extremely low.

Prof. Aug. H. Gill, in his Engine Room Chemistry says, on page 137:

Other things being equal, the least viscous oil should be chosen, or, otherwise expressed, the most fluid oil that will stay in place and do the work.

How is this to be understood? What is the proper viscosity for cylinder oil? H. B.

A. When selecting a steam cylinder lubricant, the type of lubricator and position of lubricator feed pipe are worthy of consideration. If the feed pipe is connected 6 ft. or more above the steam chest and it will feed properly through the lubricator, the heavier or high viscosity oil is preferable, other conditions being equal. If the lubricator feed pipe is connected directly to the steam chest, a slightly lighter oil is best, as it will atomize more quickly.

On the whole, viscosity tests have little bearing upon the actual lubricating value of cylinder oil. Four brands of cylinder oils having Saybolt viscosities of 120 deg., 140 deg., 170 deg. and 220 deg., at 212 deg. F., showed a tendency in a test, to approach a common viscosity at the higher working temperatures.

Saybolt viscosity is the most commonly used. In

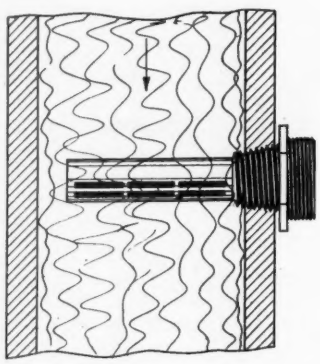
this method, when a standard amount of oil has been heated to the desired constant temperature in a cup, the bottom orifice is opened. The oil then runs into a 60 cc. flask, and the number of seconds as noted by a stop-watch that are required for the flow of oil to fill it to the 60 cc. mark is reported as the viscosity of the oil, Saybolt.

Your viscosities of 3.9 and 2.6 were relative to the viscosity of water at the same temperature. Prof. Gill's recommendation of the least viscous oil is understood to refer more particularly to bearing oils.

Actual operation, recording the amounts used, noting the condition of cylinder after a sufficient run and smoothness of running, is the best guide to the lubricating value of an oil for an individual installation.

Improving Cylinder Lubrication

WITH REFERENCE to the cylinder lubrication trouble which E. C. F. is having, it is my opinion, after carefully studying the steam connections of his engine, that his trouble may be caused by one of two things. In my 18 yr. of experience I have encountered only about two such cases, which were easily corrected.



SLOTTED FEED PIPE

First, he may overcome the condition by placing a longer nipple between his throttle and the separator. The sketch showed no scale, but I presume the length of the nipple is about 4 in. I would recommend that it be replaced by a nipple 12 or 24 in. in length. I admit that in raising the separator it may not look quite so well as it does nearer the throttle; but in so doing he will acquire the results necessary for the practical operation of his engine.

Second, I would change the discharge pipe of the forced lubricator from its present point of entrance to the nipple above the throttle valve now in discussion. If he uses a nipple 2 ft. in length, I would recommend that the lubricator pipe enter about halfway up the nipple, and in making the above connection I would further suggest threading a piece of pipe or nipple so that it may be screwed clear across the inside diameter of the steam pipe, and also bore ⅛-in. holes at one-inch intervals in it, plugging the end of the pipe. This arrangement will thoroughly mix the lubricating oil with the steam, and the elevation of its location will give the oil a great opportunity to be thoroughly atomized by the steam before it enters the working parts of his engine.

Of course, his trouble may be cured in other ways, but this prescription is about as short as any.

H. W. ROSE.

(Editor's Note.—Another suggested lubricating feed device is the method of slotting the pipe, as shown in the accompanying sketch. The end is open and should extend to a point just beyond the center of the steam line. If the pipe were screwed flush with the inside surface the oil would spread over the inside of the steam line, and only a small amount would be atomized and available for proper lubrication.)

In Trouble

IN REGARD to the advisability of license laws for engineers and firemen, as brought up in the communication of A. Owl, on page 424 of the May 1 issue, there can be no question, and it ought to be a national law, not forgetting that the object of any such law is the safeguarding of life and property.

Employers are the same everywhere, always looking for those who will work the longest hours and do the most for the least money, and in most cases the engineer is the one to blame in respect to his condition.

The only remedy is for engineers to organize and come out for their demands the same as other craftsmen have done. Then they will have the respect of their employers.

It is only within a comparatively recent period that employers have given any consideration to welfare work. The foregoing may be considered as a reply to A. Owl's statement of the 12-hr. watch. In some plants the men are always on days or nights, while in others the shifts are alternated periodically.

In some northern plants the pay of the day man is higher because he is usually held by the employer as responsible for the whole plant, and the majority of repairs are made during the day. In other plants they receive the same money and each takes care of such repairs as may come up on his shift.

Employes of the North have to a great extent asserted themselves through their organization and have been instrumental in having labor laws enacted that have shortened the length of the work day; it is evidently up to the boys in Dixie to do likewise.

In reference to the chief or any other engineer who does not read, the least that can be said is that he fails utterly to make the most of his opportunities and fails to realize his responsibilities to his family, his country and himself, and never for long holds the desirable positions should fortune place him in them.

In regard to the setting of a pop or spring safety valve, the thing to remember about most of them is that when it is desired to alter the blowing off pressure in excess of 15 lb., a new spring suitable for such pressure must be obtained.

Generally the head of the pressure screw that controls the tension on the spring is a hexagon, and turning the head one square will change the blowoff pressure about 5 lb.

Such valves have a ring or similar device which can be moved up or down in the body of the valve, and thus cause the valve to seat when the predetermined drop of pressure has been obtained. The following

formulas are those usual in making lever valve calculations. Owing to the ease with which such valves can be overloaded, they are not looked upon with favor, and they have no device to regulate the blowback, hence simmer away for a number of minutes before they close, wasting fuel and cutting their seats.

To find the pressure at which a valve will blow, the following formula may be used:

$$P = \frac{W L + w l + V D}{A D}$$

To determine the weight:

$$W = \frac{A P D - (w l + V D)}{L}$$

To find the distance from the fulcrum to locate the weight:

$$L = \frac{A P D - (w l + V D)}{W}$$

In these formulas, P = pressure in pounds per sq. in., L = distance of weight from fulcrum, W = weight on lever in pounds, V = weight of valve and stem in pounds, w = weight of lever in pounds, l = distance from fulcrum to center of gravity of lever, A = area of valve in square inches, D = distance from center line of valve to fulcrum in inches. RECEIVER.

Relieving Boiler Vibration

IN REFERENCE to the vibration trouble encountered by J. H. P., I find that that fault is frequently encountered in stationary steam plants, and if not corrected may lead to quite disastrous results. He may trace his trouble from the following causes: First, the steam line from his boilers to his engine may be too rigid, with no allowance made for vibration, and as the load upon his engine naturally varies, the working strain increases or decreases. If his engine is not upon a perfectly solid foundation it adds all the more to the trouble. I would suggest that he place a large "U" or "L" bend in the steam line, which will take up any vibration between boilers and engines.

Second, be sure that the main steam line leading either to his engine or any other portion of his plant is not bolted rigidly to any of the main walls of his plant, as at all times in a manufacturing plant there is a certain amount of vibration in the entire building. This is greater at some times than others, owing to the amount of work the machinery is doing.

If his main steam line is bolted tight to the building, then he will always have the same amount of vibration in his pipes and boilers that is in the main building, and the only way to overcome this is to suspend all of his piping upon extension pipe hangers.

H. W. ROSE.

Wood or Iron for Brine Tanks

OUR BRINE TANK leaks and will have to be replaced with a new one; but before making the change I should like to know whether one made of oak would be as good as one of iron. Which would be the cheaper?

Would I be required to cover the wooden tank?

F. P. M.

A. A brine tank made of oak planks and kept well painted, both inside and out, would serve your purpose, but it probably would not be quite as durable as an iron tank. It should, however, have some insulation, as otherwise there will be a considerable loss in refrigeration capacity.

It is usually advised that there should be on the bottom 8 in. of dry filling between support joists, planks on top of this, then a 1-in. air space, provided by spacer strips laid over the joists, then two thicknesses of tongue and groove boards, with a layer of two-ply insulation paper between; on top of these boards another 1-in. air space, formed by spacer strips, and the tank set on top of this.

On the sides the insulation recommended is a 4-in. air space outside the tank, two thicknesses of tongue and groove boards, a 4-in. space filled with non-conducting material, a course of tongue and groove boards, and a layer of insulation paper on the outside, covered with a course of tongue and groove boards placed vertical.

A. C. Wiring Calculations

WHAT SIZE wire is required to transmit 800 hp. 8000 ft. at 2200 v., 80 per cent power factor and 5 per cent loss? What is the formula and how is it worked out?

G. G.

A. You have failed to state whether your system is of the single, two or three-phase type, but we have assumed it is of the three-phase type, and therefore have based our calculations accordingly. In three-phase, alternating-current work, the current flow is calculated by means of the following formula:

$$I = \frac{\text{kw.} \times 1000}{E \times \text{p.f.} \times \sqrt{3}} = \frac{\text{kw.} \times 580}{E \times \text{p.f.}}$$

Where I is the current in amperes; kw. is the kilowatt load; E is the voltage, and p.f. is the power factor.

One electrical horsepower is equal to 746 w., so that your total load is equal to 746 × 800, or 596.8 kw. We therefore have

$$I = \frac{596.8 \times 580}{2200 \times 0.8} = 196.6 \text{ amp.}$$

Knowing the value of I, or the current flow, the size of the wire may be calculated by the employment of this formula:

$$A = \frac{10.8 \times I \times d \times \sqrt{3}}{e} = \frac{18.7 \times I \times d}{e}$$

In this formula, I is the current in amperes; d is the distance the power is to be transmitted, or 8000 ft.; e is the drop in volts, or in this case 110; A is the area of the conductor in circular mills. Substituting these various factors in the above formula we have:

$$A = \frac{18.7 \times 196.6 \times 8000}{110} = 267{,}385 \text{ circular mils}$$

IN SETTING a ladder, the horizontal distance of the foot should not be over one-fourth the length of the ladder from a vertical line through the top, unless the foot is blocked or securely held against slipping. If the footing is slippery, such as a tile or oily floor, this distance should be considerably less than one-fourth the length of the ladder.

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Bituminous Coal Production

At this time last year, a "Store Coal" campaign was in progress, and as a result the production of bituminous coal increased to a point where it was considerably greater than consumption, even though the industries were using great quantities of coal for the manufacture of munitions. Even a month before the armistice was signed, the production began to drop, for on the first of October the daily production was 2,200,000 T. The decrease was gradual until Dec. 20, when it reached 1,700,000 T. per day. This reduction in output did not stop even there, but reached its minimum the fore part of April at about 1,150,000 T. per day. There has been some increase since that date until now the production is about 1,450,000 T.; but in view of the industrial activity now prevalent and comparison with the 1917 production, which averaged about 1,750,000 T. throughout the year and which, by the way, resulted in the fuel famine during the winter of 1917 and 1918, this production is at least 300,000 T. a day short of what should be considered an absolute minimum to meet requirements.

There seems to be but one result that can come unless production is increased to a great extent during the summer months—a severe coal famine next winter.

Reports from the U. S. Geological Survey show that the loss of production is almost entirely on account of no market. This being the case, the remedy is in the hands of consumers, who undoubtedly will suffer if they wait until fall or winter to place their coal orders.

Another factor entering the situation adversely is the great number of miners and their families leaving this country to make their homes in their native lands. It is reported that hundreds of thousands have already gone. When the public in general realizes the necessity of storing coal for the winter, lack of labor, over which the consumer has no control, is most likely to stand in the way of securing adequate production, with famine prices as a result. One authority has it figured out that with present production and consumption all bituminous coal out of the mines will be burned up by April 1, 1920.

Such a situation is not pleasant to contemplate, much less experience, so we again give our readers a word of warning to make your fuel supply for the coming year secure.

The Big Hop

With great pride, Americans hail their Navy aviators who made the transatlantic jump from Newfoundland to Portugal. These aerial pilots have made remarkable advance in the work of knitting the nations together and proving that with the right type of plane and dependable engines the Atlantic trip is not a hazard.

Only the direct Newfoundland to Ireland route may be accepted as the final and complete conquest of the air above the Atlantic; but this 2200-mile flight, made in 26 hr. and 41 min. actual flying time, is a remarkable achievement. These men cleared the way, and gathered practical information that could be secured in no other way.

Mounted between the wings were four Liberty engines, each developing 400 b.hp., and with the full load

of 28,000 lb. the NC-4 carried 17.5 lb. per hp. One engine is mounted on each side with a tractor propeller, while the two remaining engines are mounted in tandem in the center, the front one having a tractor propeller and the rear one a pusher propeller. Welded aluminum gasoline tanks to feed these engines were another new feature. There were nine 200-gal. tanks made of sheet aluminum, each weighing but 70 lb. or 35 lb. per gallon of contents, about one-half the weight of the usual steel or copper tank.

To the Bureau of Steam Engineering, which was responsible for the power plants of the plane, great credit is also due. Their share in this work should not be overlooked.

Valuable Details

In the descriptions of power plants, the average reader is interested mostly in the arrangement and types of equipment, operating conditions, piping arrangements and other features conducive to safety, economy and convenience. It must not be overlooked, however, that the success of any plant is due to the consideration of the comparatively small but important details. Specifications for any given type of apparatus are so nearly alike for different plants that writers usually omit them in describing power plants except when something very unusual is provided, assuming that the readers are familiar with such details.

Erroneous assumptions are, however, sometimes made and lest Power Plant Engineering be accused of such errors, we are publishing as the leading article of this issue a description of two pumping plants which have many individual features of interest, but to our readers we believe the most valuable feature of the article is the completeness with which the details of construction of the different pieces of apparatus are given. These specifications are well worth preserving for use when making similar purchases.

Cheerful Engineering

Unfortunately, "treat 'em rough" seems to be the attitude of many men in their engine room relations—the manager with the chief engineer, and the chief engineer with the various subordinates. In conversation their abrupt unsympathetic tones may discourage or actually antagonize.

Discouragement is a killer of achievement; it prevents full co-operation and it destroys courage, which in turn blights initiative. Then we have half-hearted helpers rather than worth-while assistants.

Strive, Mr. Engineer, to create a genial atmosphere throughout the plant. Be a real friend to your workers. Maintain an optimistic attitude in your relations with fellow engineers and notice the results. It will build a constructive morale that the army considers so vitally important for success. Give genial co-operation, then you may expect to receive it. Cheerful power plant management pays.

THE LOSS of personal contact and relationship between the master and his workmen that existed in the early history of modern industry is one of the causes of present day labor difficulties.

Thrift Accelerates Investments

THE thrifty engineer will and can spend more money than the spendthrift. In the long run, it works to the advantage of every selling concern to preach thrift as much as possible among their patrons; those who do not are soon mistrusted as unreliable.

It must never be forgotten that thrift does not consist in hoarding or hiding money away and not using it. That is a very thriftless thing to do with money. Thrift consists in spending money wisely. The thrifty man spends as much or more money than the extravagant man. But he spends it for a different class of objects.

Thrifty people spend more money than spendthrifts because they have more money.

Take, for instance, one man who practices prudent economy and another who is thriftless, both receiving the same salary.

The first will spend $900 a year living. He has $100 left from his salary of $1000 a year. He puts this in reliable investments, such as War Savings Stamps.

The second man spends $1000 each year for his living expense. He has nothing left over. The first man and the second spend the same amount in the first year; but at the end of the first year the thrifty man will collect his interest on the $100 invested in government securities, which pay him no less than $4.25. This he will add to his second year's salary, making $1004.25.

Having planted the seed of economy, he undoubtedly will practice and cultivate the same frugality he did the the year before; but this time he has $1004.25 to spend. It leaves him $104.25 to invest. And so on will this scheme of affairs continue. During the third, and every succeeding year, the difference in amount spent by these two men will grow greater and greater as long as they keep their old habits with respect to thrift.

The first man is a better credit risk than the second. The first man is helping his community and his government. He is encouraging industry and business.

U. S. CIVIL SERVICE COMMISSION announces an examination for superintendent of heat treatment, to fill a vacancy in the United States Naval Ordnance Plant, South Charleston, W. Va., at $5000 a year, and future vacancies requiring similar qualifications throughout the United States. Competitors will not be required to report for examination at any place, but will be rated on the following subjects, which will have the relative weights indicated, on a scale of 100; (1) Education and preliminary experience, 30; (2) Responsible experience and fitness, 70. Competitors will be rated upon the sworn statements in their applications and upon corroborative evidence. The prerequisites for consideration for this position are: (a) A degree in metallurgical or mechanical engineering from a recognized technical college, or 6 yr. of general metallurgical or mechanical experience, or any equivalent combination thereof. (b) At least 8 yr. of additional experience in shops manufacturing ordnance material, including armor plate, large caliber guns and projectiles.

Applicants should at once apply for Form 1312, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C.

A Protection Against Reversed Phases

IF a three-phase motor is disconnected from a circuit and the phases reversed when it is reconnected, it will naturally run backward. Such a reversal may occur and has occurred when the motor is disconnected for repairs, through an error in reconnecting leads at the power house, or substation, or from a number of other causes.

FIG. 1. REVERSE PHASE RELAY

In many cases the reversal of rotation of a motor, aside from the inconvenience it causes, is not a serious matter as the error can be corrected at the motor terminals. In other cases, however, serious consequences may result. The reversal of an elevator motor, for instance, might result in wrecking the machinery and loss of life.

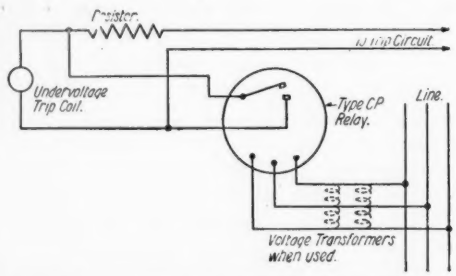

FIG. 2. DIAGRAM OF RELAY CONNECTIONS

To protect motors against phase reversal where such protection is necessary, a reverse-phase relay with positive operating characteristics has been developed. If a phase is reversed, or if a phase fails, or if the voltage drops below 75 per cent of normal, the relay contacts close and trip the circuit-breaker, either through a shunt-trip coil or by short-circuiting an under-voltage trip coil having a series reverse resistor.

The relay operates on the induction principle. When properly connected, the torque holds the contacts open against the restraint of a spiral spring. On low voltage, the torque diminishes and the spring closes the contacts. On reversal of phase connections, the reversed torque assists the spring in closing the contacts.

The contacts will close at 5 amp., 250 v. or less.

AN AMERICAN PETROLEUM INSTITUTE has been formed with headquarters at Washington to promote mutual co-operation between the petroleum industries and Government departments.

Prices and Power

UTILIZATION OF ALL PRACTICAL POWER RESOURCES WILL REDUCE PRICE OF MANUFACTURED COMMODITIES. PASSAGE OF WATER POWER BILL AND OTHER STEPS NECESSARY. BY FREDERIC J. HASKIN*

A NEW method for reducing the H. C. of L. may be added to the thousand or more that have already been suggested. Government scientists now say that the price of all manufactured commodities, from breakfast foods to battleships, will come down when the United States learns how to make economical use of its power resources.

And not only water powers. We all know that millions of horsepower are being wasted in our streams, and Congress is at work, more or less, on the water power problem. But now a drive is being started to encourage the development of electrical power at the coal mines, thereby saving the billions it costs us to haul the coal about the country by rail.

The United States is rich in the natural resources which produce power, and as a result, the development of power has proceeded in a haphazard manner. During the war, however, the nation came perilously near a power shortage. The government grew worried, and ordered a series of power investigations, the results of which show that a tremendous amount of power is going to waste in this country.

Providing for the development of water power under federal control, the water-power bill is the first step to remedy this situation. The next step will be the generation of electricity at the coal mines instead of generating it in hundreds of individual steam plants. Both of these propositions have been considered by mining engineers and scientists for many years, but it took the war to impress the need for them upon the nation.

Increased power means increased production, and the only way to lower prices is to produce more goods. A man must produce more goods before he gets a larger share of them. One of the greatest mistakes that organized labor has ever made, according to government officials, is to oppose the introduction of power and thereby of machinery. This it has done on the grounds that the introduction of machinery decreased the number of jobs. It is true, of course, that it does decrease the number of unskilled jobs, but it increases the number of skilled jobs, paying higher wages.

It is to the advantage of the unskilled workman to become a skilled workman just as soon as he can, for brain always commands a higher price than muscle. His producing capacity is raised, and he is able to command a higher wage. The American workman produces more goods than the European workman, and his standard of living is correspondingly higher.

Thus it may be seen that any shortage of power in this country would halt its industrial progress, which consists of this gradual rise of machinery and of growth in the skill of the workmen. Any great expansion in our industries can take place only through the increased development of power. Secretary Lane of the Interior, who is one of the strongest advocates of the water-power bill, declares that there must be a large increase in

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* Bridgeport, Conn., Standard Telegram.

power production during the next few years if the United States is to survive international competition.

"Only by increased economy in the production and distribution of power will it be possible for our manufacturers to decrease their production expenses and compete successfully in the world's markets," he says, "maintaining at the same time the American standard of wages and living."

Coal is the source of most of the power generated in this country, and it is one of the best examples of industrial extravagance for which the consumer ultimately pays.

One-third of the work of railroads is hauling coal from mine to market. In the markets, as much as one-fourth of this coal is used to generate electricity. Energy is the only commodity in everyday use which is not shipped in its refined state. Suppose, instead of concentrating gold at the mine, it was shipped as ore to the market centers? Or, suppose the farmer, instead of reducing his corn to the smallest weight and size, shipped it on the cob? You can see what a huge, unnecessary burden would be placed upon the railroads. The only difference between these commodities and electricity is that electricity cannot be crated and sent in a freight car. It has to have a special kind of carrier.

Because this special kind of carrier did not exist, our industries have followed the line of least resistance and have continued to import their energy in the form of coal. Under the new policy of power economy, this practice cannot go on; for the economical thing to do is to make the electricity right at the coal mine and send it to adjacent cities by wire. The system has been tried out in recent years in various places and found to be practicable. At present the maximum distance at which electricity may be successfully transported to the market from the mine is 250 miles, which is about the distance from New York to Washington.

Two large electric power plants a couple of years ago were supplying the city of Youngstown, Ohio, and adjacent small cities extending into Pennsylvania, with power. They saw that a great waste could be eliminated if the two plants combined into one power plant at the coal mine. Such a plant has now been built at the mouth of a coal mine near Wheeling, on the Ohio River, and is operating at greatly reduced costs. Electricity is being generated there and sent to several near-by cities.

Another plant of this type is in operation at a coal mine in Alabama in the Birmingham district. It has been found that in addition to saving the transportation charges of shipping coal by freight, a great saving in coal at the mines has been effected. For a large quantity of inferior coal can be used to generate electricity at the mine, which would not have been shipped, but wasted, under the old system.

These steam power plants at the coal mines sell electricity at a lower price than can several plants scattered in various cities of the district, paying freight charges on coal. The manufacturers who buy their electric power at a lower price can afford to charge a lower price for their products, and so, if there is not too much juggling among the middlemen, the ultimate consumer also reaps the benefit.

There is one other way, moreover, in which the consummer is benefited. If electricity is generated at the coal mines, the railroads are relieved of a tremendous strain. They will not wear out so quickly, and it will not be necessary to build so many new ones to keep pace with the ever-increasing demand for steam power. Any great expansion of the railroads always reacts against the consumer in two ways: The rates are raised to pay for the new construction; and the demand for large capital, such as is required to finance the construction, sends interest rates up.

If the country is going to do its best by its power resources, this development of electric power plants at coal mines must be supplemented by a thorough development of water power. Water power, where the natural site is good, is the cheapest power resource of all. In the Alabama coal mine electric power plant, for example, which makes electricity much cheaper than it could be made by a half dozen plants receiving shipments of coal from the mines, it takes 270 men working in two shifts to mine the coal and generate the electricity. In a water power plant in the same state it takes 12 men, working in two shifts, to produce just four times as much electricity.

The water-power bill now before Congress, it is prophesied in government circles, will be passed during the next session of Congress. If so, many valuable water sites will doubtless be developed during the next few years under federal control, and the great amount of power which is now going to waste will be harnessed to increase American production for foreign as well as domestic markets.

News Notes

At the forty-second convention of the National Electric Light Association, held May 19 to 22 at Atlantic City, N. J., the following officers were elected: President—R. H. Ballard, vice-president and general manager of Southern California Edison Co., Los Angeles, Cal.; first vice-president—Martin J. Insull, Middle West Utilities Co., Chicago; second vice-president—M. R. Bump, Henry L. Doherty & Co., New York City; third vice-president—F. W. Smith, United Electric Light & Power Co., New York City; fourth vice-president—W. H. Johnson, Philadelphia Electric Co., Philadelphia, Pa.; treasurer—H. C. Abell, American Light & Traction Co., New York City; executive committee (for three years)—W. H. Atkins, Boston, Mass.; P. G. Gossler, New York City; D. H. McDougall, Toronto, Ont., and (for two years) R. J. McClelland, New York City.

The Buffalo Forge Co. announces that C. C. Cheyney has returned to take charge of its Chicago office and store. Lieutenant Cheyney was commissioned in the navy and had charge of the mechanical repair shops at the Naval Aviation Station, Pensacola, Fla., where from 600 to 1200 men were employed during the war. Capt. H. H. Downes, 12th U. S. Engineers (Railway), has returned from France, and expects that after receiving his discharge he will take charge of the Buffalo Forge Co.'s interests in the St. Louis territory. Captain Downes' regiment was one of the first to go across, sailing in July, 1917.

FRANK F. FOWLE, until recently one of the receivers of the Central Union Telephone Co. and formerly consulting engineer, and James R. Cravath, well-known consulting electrical and illuminating engineer of Chicago, have formed an engineering partnership under the firm name of "Fowle and Cravath," with offices in the Monadnock Block, Chicago. Both partners are men who have made national reputations in their work and are especially well known in Chicago and the Middle West. The services of the firm will be devoted to investigations, research, design, supervision, management, appraisals and rate cases, in several fields with which the partners have heretofore been identified.

CALVERT TOWNLEY, assistant to the president of the Westinghouse Electric & Mfg. Co., was elected president of the American Institute of Electrical Engineers at the annual business meeting held on May 16, in New York City.

Mr. Townley joined the institute in 1901 and has been almost continuously active therein ever since. He has been a manager and a vice-president, has served on many committees and contributed occasional papers. During the year just past he has been an A. I. E. E. trustee, first vice-president of the United Engineering Society, a member of the Engineering Council, chairman of the Public Policy of the Development Committee and a member of the Edison Medal and other committees.

U. S. CIVIL SERVICE COMMISSION announces examinations for master computer (Salary, $1800 to $2400 a year) and computer (Grade I—$1400 to $1800, Grade II—$900 to $1400). Vacancies in the Ordnance Department at Large of the War Department, for duty at the various proving grounds within the United States will be filled from these examinations. Competitors will be rated on physical ability, education, experience and fitness. Apply for Form 1312, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C.

CHARLES A. GREENE, Chicago representative for The Borden Company, has opened up a downtown office at Room 501, No. 549 W. Washington Blvd., Chicago. The company has just purchased an Oldsmobile roadster for its representative, Geo. D. Clewell, who covers the New England States, Cleveland and Detroit. Mr. Clewell expects to work his entire territory with the car, and in this manner will be able to keep in closer contact with the small towns and also be in a position to render more thorough co-operation with the jobbers.

S. C. ORRELL, recently manager of the Minneapolis office of the Allis-Chalmers Manufacturing Co. of Milwaukee, has resigned to assume charge of the Chicago office of the Murray Iron Works Co. of Burlington, Iowa.

T. J. HUDSON, of the Chicago Pneumatic Tool Co., of Chicago, has been appointed Acting Manager of the Pneumatic Tool Sales Division, succeeding F. H. Waldron, who returns to Minneapolis, Minn., as District Manager of Sales for the Minneapolis territory.

GEORGE S. HERRICK, Syracuse, N. Y., announces the company's removal to a larger and better location at 217 N. Franklin St.

Book Reviews

THE THIRD EDITION of Examples in Magnetism by F. E. Austin is off the press. Practically no changes have been made in this book, reviews of previous editions of which have appeared in these columns.

AN INVESTIGATION of statically indeterminate structures has been conducted by the Engineering Experiment Station of the University of Illinois to obtain a convenient method of analyzing the moments, stresses and deflections for a number of typical structures. The analyses were based upon the assumptions that the connections are perfectly rigid, that the length of a member of a rectangular frame is not changed by axial stress and that the shearing deformation is zero. The method used in the analyses and the equations derived are published in Bulletin 108, entitled "Analysis of Statically Indeterminate Structures by the Slope Deflection Method," by W. M. Wilson, F. E. Richart and Camillo Weiss. The method has been explained in sufficient detail to enable the designing engineer to use it in the solution of his problems. It is believed that the fundamental principles presented may be readily co-ordinated with the ordinary principles of mechanics so that the more complex and even the simpler problems may be studied from a new viewpoint.

Copies of Bulletin 108 may be had without charge by addressing the Engineering Experiment Station, Urbana, Ill.

THE SUPERINTENDENT of one of the country's large manufacturing plants has given emphatic testimony regarding the benefits of industrial training, in a recent bulletin issued by the U. S. Training Service of the Department of Labor. The pamphlet is entitled "A Business Man's Experience with Industrial Training," and E. A. Barnes, superintendent of the General Electric plant at Fort Wayne, Ind., is the author. Mr. Barnes believes that industrial training as promoted by the Training Service should be generally adopted in American industries.

"In too many cases," he says, "the old system of letting shop foremen hire men without much consideration for the applicant's ability or training is still in effect, with the result that many new employes spoil work, ruin expensive machinery and tools and really produce little work that is perfect enough to be shipped."

After reviewing the benefits which came from establishing training in his plant to meet the war emergency, Mr. Barnes goes on to tell of his conversion to the permanent value of training. He found that his foremen were especially anxious to secure the workers who had been through the training department, which fact of itself was strong endorsement of the idea. Experience with what was first considered a temporary feature led to making it permanent. To this training department all new employes are sent, and also old employes who from lack of proper training are not doing as well as they might. Mr. Barnes lays special emphasis on the fact that training gives employes broader opportunities.

This bulletin is one of a series dealing with industrial training any of which can be had free of charge by addressing the U. S. Training Service, care of the Department of Labor at Washington.

These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should preserve them. A handy, serviceable, loose-leaf cover in which these tables fit exactly, will be sent you for 30 cents in currency or stamps.

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POWER PLANT ENGINEERING
OPERATING CHARACTERISTICS OF 60,000-KW. 3-CYLINDER TURBINE WITH HIGHER STEAM PRESSURES
HEAT AVAILABLE IN ADIABATIC EXPANSION TO 29" VAC. REF. TO 30" BAR.
TOTAL HEAT OF STEAM, B.T.U.
RANKINE CYCLE EFFICIENCY OF TURBINE AND GEN. IN PER CENT (GEN. EFF. = 94.0 %)
STEAM PRESS. - LB. ABS.
KW HR. PER LB. = WATER RATE
1320
1300
1280

POWER PLANT ENGINEERING
RELATIVE ECONOMY OF COAL AND OIL AS FUEL, CHARTS A AND B
BOILER EFF. WITH 13800 B.T.U. PER LB COAL
BOILER EFFICIENCY WITH DIFFERENT COALS
CHART A
EQUIV. EFF. WITH COAL
HEATING VALUE OF COALS
B.T.U. PER LB.
BOILER EFF.- OIL FUEL NET LESS 4% FOR BURNERS
CHART B
RELATIVE ECONOMY COAL AND OIL NET EFF. WITH OIL 4% ABOVE THAT WITH COAL.
BBL. OIL OF 336 LB. PER BBL. & 18500 B.T.U. PER LB. (6,216,000 B.T.U. PER BBL.) / TON COAL

POWER PLANT ENGINEERING
CURRENT RATINGS FOR 13,200-V. CONDUCTOR CABLES
MAXIMUM CONTINUOUS LOAD IN AMPERES
NOTE. MAXIMUM TWO HOUR OVERLOAD RATING MAY BE TAKEN AS 10% INCREASE OVER THE CONTINUOUS RATING.
350,000 C.M.
250,000 C.M.
4/0
2/0
1
TEMP. OF AIR IN IDLE DUCT - FAHR.
TEMP OF OUTSIDE AIR - FAHR.

DATA TO BE USED IN THE DESIGN OF SILENT CHAIN DRIVES

Pitch, inches	¼	⅜	½	⅝	¾	1
Minimum number of teeth:						
Small sprocket driver	13	13	15	15	17	17
Small sprocket driven	17	17	25	29	31	35
Desirable number of teeth in small sprockets	15-17	17-21	17-23	17-23	17-27	17-31
Maximum number of teeth in large sprockets. (See Note 3)	99	109	125	129	129	129
Desirable number of teeth in large sprockets	55-75	55-85	55-95	55-105	55-115	55-115
To find pitch diameter of teeth by multiply number of teeth by	0.159	0.199	0.239	0.2965	0.382	0.477
Addendum for outside diameter of sprocket. (See Note 1) inches	0.10	0.12	0.15	0.18	0.24	0.30
Maximum R.P.M.	2,400	1,800	1,300	1,100	800	600
Tension per inch width chain, pounds: Small sprocket driver	80	100	120	150	200	270
Small sprocket driven	65	80	95	120	160	210
Radial clearance beyond tooth required for chain, inches	0.50	0.62	0.75	0.90	1.2	1.5
Approximate weight of chain per inch wide, 1 foot long, pounds	1.00	1.30	1.50	1.80	2.50	3.00
C' for solid pinions	0.0045	0.0063	0.009	0.013	0.023	0.036
C' for armed sprockets	0.16	0.25	0.35	0.45	0.7	1.0

Pitch, inches	1¼	1½	2	3
Minimum number of teeth:				
Small sprocket driver	15	17	17	17
Small sprocket driven	25	29	31	35
Desirable number of teeth in small sprockets	17-23	17-27	17-31	19-31
Maximum number of teeth in large sprockets. (See Note 3)	125	129	129	131
Desirable number of teeth in large sprockets	55-105	55-115	55-115	55-115
To find pitch diameter of teeth by multiply number of	0.3925	0.477	0.636	0.955
Addendum for outside diameter of sprocket. (See Note 1) inches	0.24	0.30	0.40	0.60
Maximum R.P.M.	800	600	400	250
Tension per inch width chain, pounds: Small sprocket driver	300	270	450	750
Small sprocket driven	190	210	350	600
Radial clearance beyond tooth required for chain, inches	1.2	1.5	2.0	3.0
Approximate weight of chain per inch wide, 1 foot long, pounds	2.50	3.00	4.00	6.00
C' for solid pinions	0.023	0.036	0.068	0.145
C' for armed sprockets	0.7	1.0	2.0	4.0

APPROXIMATE WEIGHTS FOR SOLID AND ARMED SPROCKETS

T = Number of teeth. F = Face in inches. C = Constant in pounds per inch in face per tooth as per table.
Weight of armed sprocket = $T \times F \times C$.
Weight of solid pinion = $T \times (F+1) \times C$.

Public Service Elect. Co.

RELATIVE ECONOMY OF COAL AND OIL AS FUEL, CHARTS C AND D
CHART D
PRICES OF COAL AND OIL FOR EQUIVALENT HEAT:
$6.00 PER TON
5.50
5.00
4.50
4.00
3.50
3.00
2.50
2.00
PRICE OF OIL PER BBL.
BBL. OF OIL OF DIFFERENT DENSITIES
THOUS. OF B.T.U. PER BBL. OF OIL
CHART C
QUANTITIES OF DIFF. OILS FOUND IN HEAT UNITS.
BBL. OIL OF 336 LB. PER BBL. @ 18500 B.T.U. PER LB (6,216 000 B.T.U. PER BBL.)
C. C. Moore & Co.

DATA ON DUCT SIZES

LOCATION	DUCTS SIZE	DUCTS KIND	DUCTS NUMBER PER BANK	DUCTS APPROX. WIDTH OF BANK	CABLE CONDUCTOR SIZE	CABLE MAXIMUM VOLTAGE	CABLE KVA.	REMARKS
BALTIMORE *	3½"	TILE	20	9"	⅜-3 COND	9.5/16	26000	HAVE FOUND 3½" DUCT LARGE ENOUGH.
	3½"				500,000 C.M. 3 COND.		8000	3½" TILE DUCT PREFERRED IN 1918 BUT NOT REQUIRED IN 1919. LEAD SHEATH OF CABLE SHOULD BE CONCENTRIC WITH DUCT IN ALL SECTIONS SINCE THIS PROVIDES MAXIMUM CAPACITY.
NEW YORK	3"	SINGLE TILE	18	2.62"	350,000 C.M. 3 COND.	14.1	6600 / 15000	3500 KVA. 13500 KVA. PREFER FIBRE DUCTS AS CHEAPER AND EASIER FOR ILLUSTRATED CONDITIONS. NUMBER OF SMALL DUCTS INSTALLED LOWER THE MAXIMUM OF SMALL CABLES INSTALLATION
LOS ANGELES	3"	FIBER	20	2.96"	10.37	⅜-3 COND		5000 LOWER THE MAXIMUM OF SMALL CABLES INSTALLATION (4700 VOLTS) 350,000 C.M. 3 CONDUCTOR CABLES.
DETROIT	3½"	SINGLE TILE	20	2.82"	8.6	½-3 COND	9.7/32 24000	7000 FAVORABLY DISPOSED TO INSTALLING FIBER DUCTS. LOWER COST AND BETTER CONSTRUCTION.
	3½"	SINGLE FIBER						
MONTREAL	3½"	TILE OR FIBER	18	3.08"		⅝-3 COND	13000	220 BELIEVE 3½" DUCT IS LARGE ENOUGH TO ACCOMODATE CABLES. SHOULD BE CONCENTRIC WITH DUCT ON CABLE. PREFERS SINGLE TILE AND THEY ALLOW HEAT TO MORE RAPIDLY
PITTSBURGH	3½"	TILE		2.7"	10	1,000,000 C.M. DUPLEX		10000 MAX. 2300 CONTIN PREFER 3½" DUCT CABLE EASILY INSTALLED IN 3½" DUCT. TILE DUCT CHEAPER AND GOOD INSULATION WHEN RAPIDLY DRAWING CABLE. CABLE BURNS OUT IN DUCT. EXPERIENCES LESS ELECTROLYSIS WITH TILE DUCT.
BOSTON	3½"	FIBER	16	3."	11	500,000 C.M. 3 COND.	9/16 25000	FIBER DUCT PREFERRED. CHEAPER AND ARE RESISTING. 3½" DUCT LARGE ENOUGH.
CHICAGO	3½"	STONE	20	3"	11	250,000 C.M. 3 COND.	22000	PREFER STONE DUCT. CHEAPER AND ARE RESISTING. 3½" DUCT WOULD BE PROPER SIZE.
LOUISVILLE	3½(O.D.)	TILE AND FIBER	16	2.625"	9.2	350,000 C.M. 3 CONDUCTOR	13000	5000 MAX. PREFER TILE DUCT. BETTER CONSTRUCTION AND LOWER COST.
	3½(I.D.)	FIBER (NEW)						PREFER FIBER DUCT. BETTER CONSTRUCTION AND LOWER COST. 3½" DUCT OF SUFFICIENT MAXIMUM POWER WHICH
NEWARK	3½"	FIBER	24	2.9"	10.3	500,000 C.M. 3 COND.	9/16 24400	9000 MAX. 2300 CONTIN ACCOMODATE CABLES INSTALLED IN ONE CABLE. SHOULD BE CONCENTRATED IN ONE CABLE.

* MUNICIPAL CONDUITS

N. E. L. A. Committee.

DATA TO BE USED IN THE DEISGN OF SILENT CHAIN DRIVES

Note 1.—Number of teeth = T. Exact outside diameter = D. For T less than 32 teeth, D = pitch diameter. For T more than 32 teeth, D = pitch diameter + (2 × addendum).

Note 2.—Use sprockets having an odd number of teeth whenever possible.

Note 3.—When specially authorized, a larger number of teeth than shown may be cut in large sprocket.

Note 4.—Thickness of sprocket rim, including teeth, should be at least 1.2 times the chain pitch.

Note 5.—The number of grooves in the sprocket, their width and distance apart, varies according to pitch and width of chain. In every case leave the designing and turning of these grooves to the manufacturer.

Note 6.—The width of the sprocket should be ⅛ to ¼ inch greater on small drives, and ¼ to ½ inch greater on large drives than normal width of the chain.

Note 7.—An even number of links in the chain and an odd number of teeth in the wheels are desirable.

Note 8.—Horizontal drives preferred. In general, slack chain should be on top but for short drives running at high speed it is desirable to run chains with slack on bottom.

Note 9.—Adjustable wheel centers desirable for horizontal drives and necessary for vertical drives.

Note 10.—Avoid vertical drives.

Note 11.—Allow a side clearance for chain (parallel to axis of sprockets and measured from nominal width of chain) equal to the pitch.

Note 12.—Desirable linear velocity for commercial service 1000 to 1500 feet per minute.

These data are for use in preliminary design. Engineering features should always be submitted to the manufacturer for approval before ordering.—Morse Chain Co.